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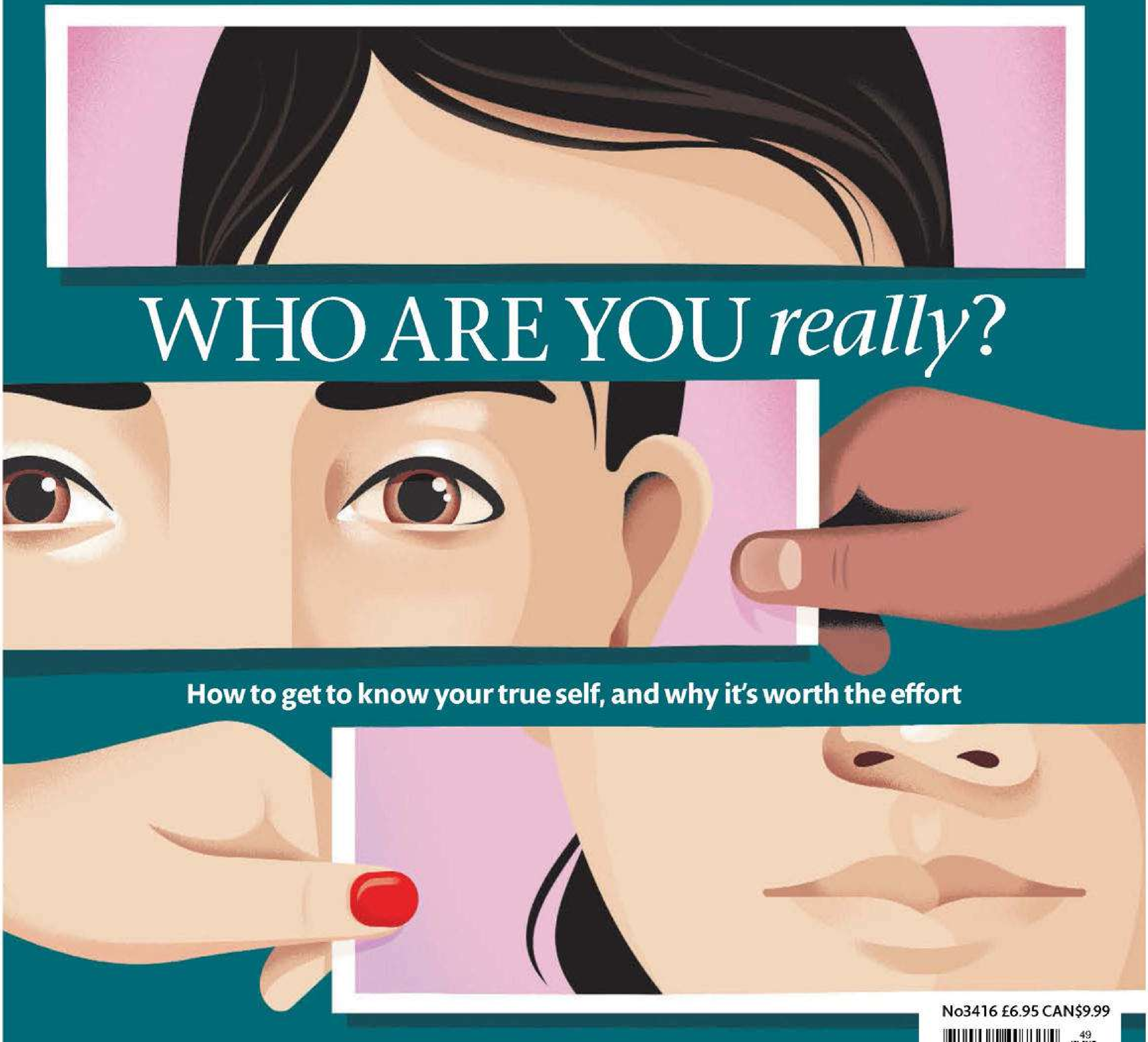
WEEKLY 10 December 2022



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Podcast

Weekly

Podcast editor Rowan Hooper talks to Henry Gee, senior editor at the journal *Nature* and author of *A (Very) Short History of Life on Earth*, which has won the 2022 Royal Society science book prize. There is also a preview of the COP15 biodiversity summit taking place this month and news of an exciting race among private companies to land on the moon. Plus, Rowan and the team learn that when female mice sniff certain types of mouse urine, it can lengthen their lifespan.

newscientist.com/nspod

ANDREY NEKRASOV/GETTY IMAGES

Jellyfish-like Marvel at marine organisms called siphonophores

MODVION

Timber towers The case for making wind turbines from wood

Video

Jet propulsion

On our YouTube channel this week there is footage of marine creatures called siphonophores, which are colonial organisms related to jellyfish. Siphonophores move using dozens of tiny sacs that shoot out jets of water. When the sacs fire together, the animals can move at speed. Firing them individually lets a siphonophore move slowly but more efficiently.

youtube.com/newscientist

Newsletter

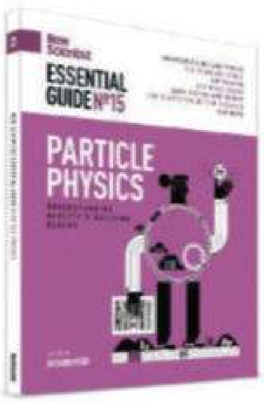
Fix the Planet

As politicians discuss lifting a de facto ban on building onshore wind farms in England, environment reporter Madeleine Cuff looks at a handful of start-ups with plans to build turbine towers and blades from wood rather than steel, concrete and fibreglass. Advantages include cutting down on manufacturing emissions.

newscientist.com/fix

Podcast

> **"It's an 8 per cent increase in lifespan, so it's pretty big"**



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The real you is worth knowing

Subjectivity is part of research on self-knowledge, but that doesn't make it useless

WHO am I? It is a simple yet profound question, long considered worth grappling with on the basis that self-knowledge is good. Take personality, for instance. Intuitively at least, it makes sense to think that if you know your personality, you will make wiser life decisions, have better relationships and ultimately enjoy greater well-being.

That may be true, but studying how accurately we perceive our personality, the subject of our cover story on page 36, is fraught with difficulties. The fact is there is no objective perspective on your personality in the same way there is if you are studying, say, subatomic particles.

Add psychology's shaky reputation when it comes to its findings holding up to repetition and scrutiny and it is easy to see why many people raise an eyebrow at the idea that we can bring scientific rigour to the question of self-knowledge.

However, psychologists have found ways to overcome many of the obstacles to studying how well we judge ourselves, testing self-reported perceptions against third-party observations of behaviour and, more commonly, the perceptions of others. The insights are enlightening. They reveal common pitfalls in self-knowledge that hint at how we might see ourselves more accurately. And it is vital that we do. Self-perceptions and the way that others see us are some of the most important influences on our lives.

> "Self-perceptions and the way others see us are important influences on our lives"

So while insights into personality may not reach the threshold of objective "truth" that some fields would demand, we should also recognise that subjective experience is what makes our state of consciousness so famously hard to study. Perhaps embracing this subjectivity is a vital part of fathoming this phenomenon.

That isn't to say that psychology is off the hook. It should, of course, finesse its methods and seek new ones, but in the meantime we can use the tools at hand to try to shine at least a little light on the truth about our personalities and whether they align with the perceptions of others. As the holiday season looms for many, our loved ones may well thank us. ▮

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This should be front page news this Christmas

Almost 30,000 young people are facing homelessness this winter*.

Young people like Simon are being forced to breaking point.

The odds are stacked against young people like Simon. Leaving the care system, Simon found himself homeless and alone in an adult world. He could barely scrape together enough money to survive and would often go to sleep hungry. With support from Centrepoint, Simon has since made strides to independence, but the cost-of-living crisis is making even the smallest steps feel near impossible for him and thousands of other young people. So this Christmas, will you help a young person at breaking point find their way forward? Sponsor a room at Centrepoint, and you'll give a young person safety, stability, and life-changing support.

Make this Christmas the turning point

94% of homeless young people move on positively from Centrepoint, into a job, education or their own home.

This Christmas, please sponsor a room for £12 a month and help a young person turn their life around.

Visit: centrepoint.org.uk/simon
Scan with your smartphone camera
Or call: 0800 473 01 86

*Based on Centrepoint's estimate on the number of young people presenting as homeless to a local authority in England from October - December 2022, using Centrepoint's Databank data from 2017-2022.

Simon's story is based on the real experiences of young people at Centrepoint. We change names and use models to protect identities.

centre point give homeless young people a future

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Your donation will go towards funding Centrepoint's vital work all year round with young people, providing accommodation and support. © Centrepoint 2022. Centrepoint Soho, operating as Centrepoint, is a charity registered with the Charity Commission of England and Wales under number 292411 whose registered office is at Central House, 25 Camperdown Street, London, E1 8DZ and a company limited by guarantee registered in England and Wales under number 01929421.

RW2A

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Early bird
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MUNTAKA CHASANT/SHUTTERSTOCK

A forest cut down for agriculture in south-west Ghana

Biodiversity

COP15 aims 'unrealistic'

Goal to "halt and reverse" biodiversity loss by 2030 could take 80 rather than eight years to achieve, reports **Madeleine Cuff**

THE COP15 biodiversity summit, which began this week, is at risk of setting the world "unrealistic" targets that may undermine conservation action, researchers have warned.

Negotiators from most of the world's countries are gathering in Montreal, Canada, from 7 to 19 December to thrash out a global plan to save nature. The central aim of the conference is to agree a new suite of targets that will "halt and reverse" biodiversity loss by 2030 and have humans living "in harmony" with nature by 2050, according to draft agreements published in June 2022.

But even the most optimistic models suggest that the earliest date possible to halt and reverse biodiversity loss is by 2050, says David Obura at Coastal Oceans Research and Development in the Indian Ocean (CORDIO), a non-profit organisation in Kenya. "Even that's based on the most simplistic assumptions, it doesn't even accommodate climate change," he says.

Global biodiversity has been declining for decades. In October, conservation organisation WWF warned that studied populations of mammals, birds, amphibians, reptiles and fish have seen an average decline of 69 per cent since 1970.

Now, in an article on what it will take to achieve a turnaround, Obura and his colleagues say reversing these declines can't be achieved in just eight years. The goals have "unrealistic expectations and time frames of biodiversity recovery", writes the team (*One Earth*, doi.org/jpnp).

"It sounds great, we want to do it… but I think the inertia in the system is such that it is just not possible," says Obura.

69%

Average decline in wildlife populations since 1970

"It takes time for organisms to grow, especially large-bodied ones like trees or large herbivores," he says. "It can take 100 years or more for an ecosystem to really go through successional stages that matter, to get to an end point that counts for what we want."

Obura says the aim of COP15 should be to "bend the curve" of biodiversity loss as fast as possible without rigid deadlines. Reaching a point where humans live in harmony with nature is likely to take at least 80 years, he says.

His wariness over the 2030 and 2050 goals is shared by other conservation experts. Tom Oliver at the University of Reading, UK, says full recovery of nature isn't possible within a couple of decades. "It may be splitting hairs, but new targets can more correctly talk about habitats on the 'road to recovery' rather than fully recovered by 2050," he says.

Mark Burgman at Imperial College London also says that the targets are "very unlikely to be met".

Setting unachievable aims risks a repeat of the failure of the Aichi Targets, write Obura and his colleagues. The Aichi Targets were 20 biodiversity goals agreed in 2010 that the world failed to achieve. Obura is concerned that another collective failure would damage confidence that change is possible, undermining immediate and long-term actions and commitments.

But some conservationists say ambitious targets are necessary to communicate the urgency and scale of action needed.

E. J. Milner-Gulland at the University of Oxford says the 2030 goal is very ambitious, but delaying that deadline "risks governments kicking the can down the road in terms of the fundamental systemic change we need".

"Even if we can't make it, we need to start to put serious effort into trying, and I don't believe that a delayed target will provide the urgency that we need," she says. ▮

Ancient humans

Was *Homo naledi* a fire starter?

An extinct human species seems to have used fire for cooking and illumination, despite its small brain and primitive features, reports **Alison George**

ARCHAEOLOGICAL evidence suggests that *Homo naledi*, a primitive human species with a chimpanzee-like skull, used fire to cook food and navigate dark caves, despite having a brain one-third of the size of ours.

"We have massive evidence. It's everywhere," says Lee Berger at the University of the Witwatersrand in South Africa. "Lumps of charcoal, thousands of burned bones, giant hearths and baked clay."

The find is still being analysed and remains controversial, but may transform our understanding of the emergence of complex behaviours only expected in large-brained species, such as *Homo sapiens* and Neanderthals.

Fossil bones of *H. naledi* were first discovered in 2013 in the Rising Star cave system in South Africa, and declared a new species in 2015. We now know it was about 144 centimetres tall on average and weighed around 40 kilograms. It had a strange mix of primitive and modern features, with ape-like shoulders and a brain little bigger than a chimpanzee's.

Dating of its remains has shown that it lived between 230,000 and 330,000 years ago, meaning it could have co-existed with *H. sapiens*, which evolved in Africa around 300,000 years ago.

> **"We have massive evidence. Lumps of charcoal, thousands of bones, giant hearths and baked clay"**

But questions remained about how *H. naledi* navigated through the underground passages at Rising Star, which are in complete darkness and require complex manoeuvres through gaps in the rock just 17.5 centimetres wide.

This inaccessibility means that, in the past decade, only 47 people – all small and slightly built – had managed to access the Dinaledi chamber, where *H. naledi* fossils were first found. But in August, Berger, who is 188cm tall, decided to risk entering this labyrinth, losing 25 kilograms of weight to do so. "I'm by far the largest person who's even been in," he says. He knew there was a chance he might not be able to get out. "I almost died on the way out," he says.

When Berger entered the Dinaledi chamber and looked up, he realised there were blackened areas and soot particles on the rock. "The entire roof of the chamber is burnt and blackened," he says.

Keneiloe Molopyane, also at the University of the Witwatersrand, uncovered a tiny hearth with burnt antelope bones in another part of the cave system, then a large hearth next to it 15cm below the cave floor. Berger also found a stack of burnt rocks, with a base of ash and burnt bones.

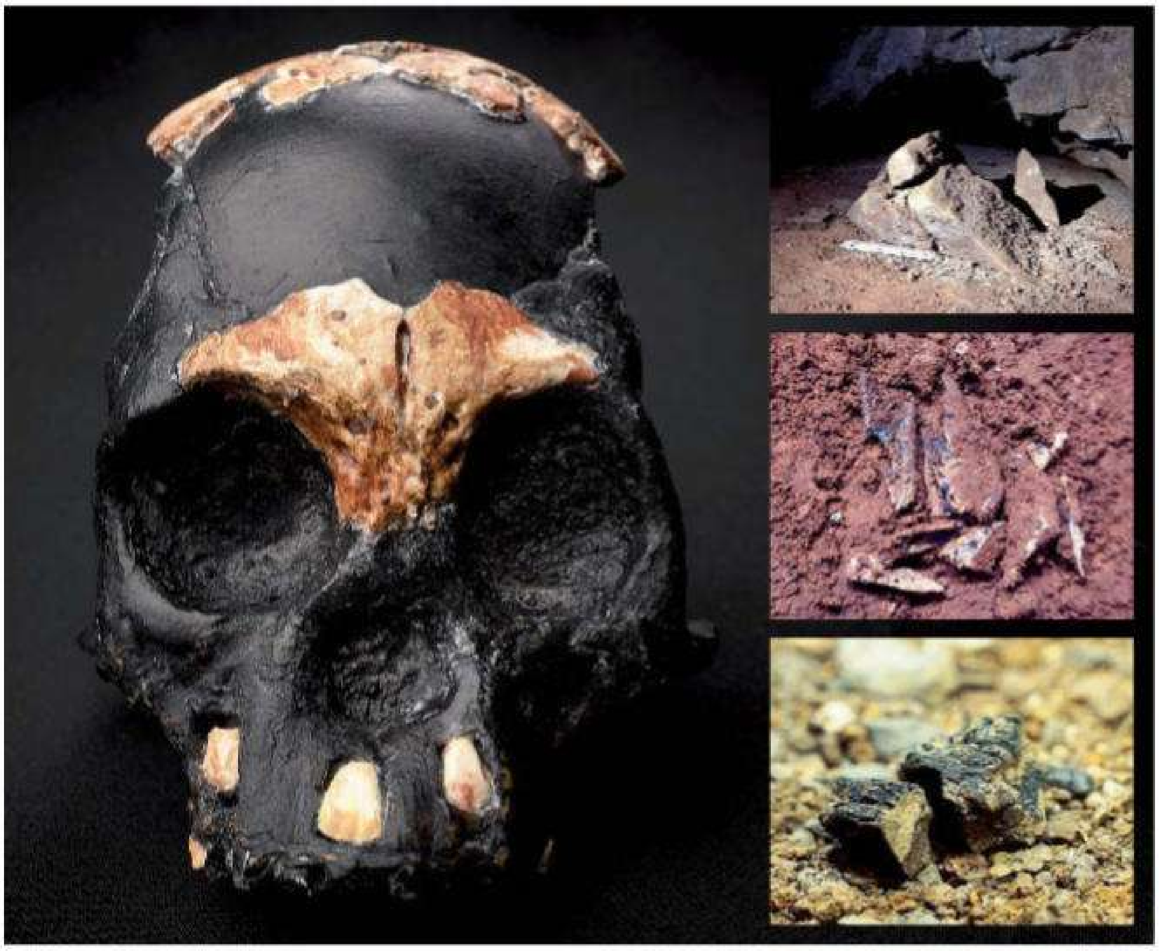
This is a remarkable discovery, as many researchers thought it was impossible for such a small-brained hominin to use fire within a cave system. While we have evidence that ancient humans living in what is now Kenya could control fire up to 1.5 million years ago, this capacity "is typically associated with larger-brained *Homo erectus*", says Berger.

Dating of the charred remains is still underway, so the decision to announce the fire discovery in a talk on 1 December, prior to the publication of the formal scientific analysis, has proved controversial.

"It's impossible to evaluate Lee Berger's claims properly without seeing the full evidence, but apparently that is forthcoming," says Chris Stringer at the Natural History Museum in London. "With all due respect to Lee and his teams for a series of great finds, this is not the way to conduct science or progress scientific debate about potentially very important discoveries."

However, for Francesco d'Errico at the University of Bordeaux in France, the discovery could give fresh insight into these extinct humans, including how they treated their dead. "The control of an artificial light source allows the organisation of actions in space and time and, in the case of mortuary practices, facilitates the participation of several members of the group in collaborative and shared actions," he says.

Berger says the implications are even more revolutionary. If these small-brained humans were capable of the complex cognition required to control fire, then "we're beginning to see the emergence of a cultural pathway and behaviour that we thought, until this moment, was the domain of [us and Neanderthals]", he says. ■



Main image: Reconstructed skull of a *Homo naledi* child

Inset: A hearth (top), burned bones (middle) and charcoal (bottom), all possibly used by *Homo naledi*

BRETT ELOFF PHOTOGRAPHY; INSET IMAGES: LEE BERGER

For more on ancient humans, see page 32

Neuroscience

Baby fruit fly's brain is largest to be completely mapped so far

Michael Marshall

THE connections within the whole brain of an infant fly have been mapped, creating the largest such "connectome" described to date.

The work should allow researchers to understand how signals travel through a fly's brain, how different regions of the brain interact and, ultimately, how specific behaviours are generated at the neural level.

Brains are mostly made of cells called neurons, which have long branches linking them together. Neighbouring neurons can signal each other at junctions between the cells called synapses, where one neuron releases a chemical called a neurotransmitter and the other receives it. The map of the neurons in a brain and the synapses is called the connectome.

The new whole-brain connectome, created by Marta Zlatic at the University of Cambridge and her colleagues, is that of the larva of a fruit fly, *Drosophila melanogaster*, a standard laboratory animal whose biology is known in detail.

To do this, her team took the brain of a 6-hour-old larva, cut it into 4841 slices and scanned them with an electron microscope. The images were then digitised and studied with the aid of computer analysis until all the neurons could be tracked from slice to slice and all synapses identified. The resulting three-dimensional map includes 3013 neurons and 544,000 synapses (bioRxiv, doi.org/jpmw). Zlatic declined to be interviewed about the work, but others in the field commented.

"All neurons of the brain are reconstructed and all the connections have been analysed," says Gáspár Jékely at the University of Exeter in the UK. He calls the research "very significant".

SURAPOL USANAKUL/ALAMY

Fruit flies (*Drosophila melanogaster*) are a common lab animal

"What is amazing here is just the sense of completion," says Catherine Dulac at Harvard University. The map reveals the "deep logic" of the neurons' connections, she says.

Just mapping synapses doesn't give you the full picture though, says Scott Emmons at the Albert Einstein College of Medicine in New York, who in 2019 produced connectomes for both sexes of the nematode *Caenorhabditis elegans*, which has 302 neurons in its entire body. Neurons can also talk to each other through slow-release chemicals like hormones and other connections between the cells, called gap junctions. All of these must be taken into account, he says, and he included gap junctions in his *C. elegans* connectomes, but the new connectome only has synapses.

In total, Zlatic's team identified 90 types of neuron in the fly brain, each with a distinctive shape, pattern of connections and proposed functions, and also described the extent of the connections across the whole brain. Most sensory information coming into the fly's brain propagates very quickly, says Dulac, taking just three hops from brain cell to brain cell to reach output neurons that help control the rest of the body. Furthermore, 62 per cent of neurons received information from every one of the larva's senses. While the details are different, these overall patterns are similar to those found in other connectomes like that of *C. elegans*.

3013

Neurons in the fruit fly larva connectome

The whole-brain connectome for *D. melanogaster* is the latest done for a handful of relatively simple animals. The first, in the 1980s, was *C. elegans*. More recently, in 2020, Jékely and his colleagues described over 1500 neurons in the connectome of a larva of a marine worm called *Platynereis dumerilii*.

In a separate study just out, Alexander Kunin at Baylor College of Medicine in Houston, Texas, and his colleagues have developed a computational method to identify groups of interconnected neurons. They applied it to an existing connectome of about two-thirds of the brain of an adult *D. melanogaster*. Some of the groups of interconnected neurons contained thousands of brain cells and comprised smaller groups of cells nested inside each other (bioRxiv, doi.org/jpmx).

Other groups are working on the connectomes of animals with much larger brains. However, because the data sets are vast, reconstructing such connectomes is a challenge.

The next big milestone is to map the brain of a mammal: first a mouse and eventually a human. Given the rate at which computer technology is advancing, some researchers think the former will be possible within the next decade.

The human brain is an even bigger challenge, as it requires a data set 1000 times larger than the already enormous one that will be required for the mouse. It also isn't clear what we could learn from our connectome without first understanding simpler brains like that of the fruit fly larva in detail. However, in the long run, a human connectome could help us understand our minds and behaviours, including the biological roots of mental illness.

"We're dealing with such big questions," says Kunin. "What causes neurodegenerative disease? What causes us to think? They're such big, complicated questions that being able to see a whole brain at the same time, I feel like it has to be part of the answer." ▮

Solar system

Huge plume of rising hot rocks may be shaking Mars...

Leah Crane

A STRANGE system of trenches on Mars may be hiding an enormous plume of hot rock rising from the planet's core. This could upend our ideas of Mars as a mostly geologically static world and explain why so many marsquakes start near these fissures, in an area known as Cerberus Fossae.

Mars doesn't have plate tectonics, and after a long period of volcanic activity 3 billion to 4 billion years ago, things have largely been calm there. But recent studies, particularly measurements of marsquakes by NASA's InSight lander, have indicated that something strange might be going on at Cerberus Fossae, which is in a region called Elysium Planitia.

Nearly all of the major quakes InSight has measured originated there, and it has felt a low, constant rumble of seismic activity that seems to come from nearby. Other observations have also suggested that the area might have been volcanically active just tens of thousands of years ago, far more recently than anywhere else on Mars.

Adrien Broquet and Jeffrey Andrews-Hanna at the University of Arizona hypothesised that this could all be explained by a phenomenon called a mantle plume, in which hot material from near the planet's core begins to rise through the mantle of the planet, causing shaking and volcanic activity as it goes. "If you were to touch a mantle rock at its mantle temperature and pressure, it would definitively feel solid. But on a million years timescale, it will flow," says Broquet.

If there is a mantle plume, it ought to press up on the crust above it, creating a large hill and fracturing the ground. Cerberus Fossae has exactly those characteristics, and computer models of how the area would evolve over time with a mantle plume pressing upwards were an exact match. The models suggested that the plume measures more than 3500 kilometres across and is up to 285 degrees hotter than the surrounding area (*Nature Astronomy*, doi.org/jpn2).

285

Difference in degrees between the plume and surrounding area

"This work provides an important crack in our understanding of Mars as a geodynamically dead planet," says Sue Smrekar at NASA's Jet Propulsion Laboratory in California. "It makes a compelling case for a stealthy but active mantle plume beneath Elysium Planitia."

Not only would that explain why there are so many quakes there, it would also solve the long-standing mystery of how the strange landscape of Cerberus Fossae formed. "Having a mantle plume there is the only way to create the fissures that make up Cerberus Fossae," says Broquet. "If not for this, the region should be in compression as the planet cools and shrinks."

The heat from a plume would also melt some of the material above it, creating magma that may eventually seep out onto the surface. In fact, the seismic activity detected by InSight is probably related to magma rising through the ground, Broquet says.

That warmth could also be a boon for the potential of life on Mars. "The plume may also provide the heat to melt water underground, and I don't want to be too optimistic, but on Earth this is an environment where microbes flourish," says Broquet. ▮

NASA/JPL-CALTECH/UNIV. OF ARIZONA

Fissures on Mars in an area known as Cereberus Fossae

...while impact crater that caused Martian megatsunami traced

ABOUT 3.4 billion years ago, a colossal tsunami swept over the face of Mars after an asteroid slammed into one of the planet's oceans. Now, researchers think they have found the crater where this megatsunami began. The size of the crater hints that the impact was similar to that of the Chicxulub asteroid on Earth, which is thought to have killed off the dinosaurs.

Alexis Rodriguez at the Planetary Science Institute in Arizona and his team combined data from several Mars orbiters to undertake a search for the impact site of the asteroid that caused this megatsunami. They found a crater 110 kilometres wide called Pohl in the northern lowlands of Mars that seems just right. It sits atop channels that probably formed as the area first flooded, creating a huge ocean, but there are deposits thought to have come from a later tsunami on top of it. That means it almost definitely formed in the right time period, before Mars dried out.

The researchers found that the asteroid that created the crater was either about 9 kilometres across or 3 kilometres across, depending on the properties of the ground it hit. Either way, it probably generated a megatsunami with 250-metre-tall waves reaching as far as 1500 kilometres from the impact site (*Scientific Reports*, doi.org/jn8q).

"You would have seen this massive wall of turbulent, reddish water, with some of it flying upwards and falling back into the wave along with rocks and soil," says Rodriguez. Mars has lower gravity than Earth, so the water and debris would fall more slowly than it does on Earth. The impact would have generated a seismic wave that propagated hundreds of kilometres, throwing dirt and rocks into the air and creating a catastrophic flow of debris along with the wave. "Very terrifying, definitely nothing to surf on," says Rodriguez. ▮ LC

Social media

Twitter quitters haven't left yet

Many Twitter users announced they would move to Mastodon, but few actually have

Chris Stokel-Walker

ONLY a handful of Twitter users who have threatened to leave the social network for open-source alternative Mastodon have actually deleted their Twitter accounts.

An analysis of more than 140,000 Twitter users shows that although plenty of people have said they are leaving the site, only 1.6 per cent of these have wholly abandoned the platform, which was bought by entrepreneur Elon Musk in late October.

"I'm not hugely surprised, because I'm one of those people that still posts on both," says Gareth Tyson at the Hong Kong University of Science and Technology, who did the work with Haris Bin Zia and Ignacio Castro at Queen Mary University of London. Tyson believes that some "thought leaders" immediately jumped onto Mastodon, but most users are "laggards" who would require a certain percentage of their followers or the people they follow to move to Mastodon, or another site, in order to jump too.

SHUTTERSTOCK/DAVIDE BONALDO

Mastodon has grown in popularity since Elon Musk bought Twitter

Castro says one concern Twitter users might have about deactivating accounts is that their usernames could be picked up by impersonators on Twitter.

To get the data, the researchers tracked 1.9 million tweets that contain phrases or hashtags that suggest the user is thinking of abandoning Twitter, such as #ByeByeTwitter or #RIPTwitter. They then analysed the Twitter users' profiles to see if they had posted a corresponding Mastodon username. Around two-thirds of the Twitter users signed up to Mastodon with the same name.

There was a small spike in the number of users who posted their Mastodon username on Twitter in an attempt to port over their audience to the new platform in the days after Musk announced he had bought Twitter on 27 October. Around 30,000 users posted a Mastodon link on 28 October.

However, the number of tweets doing this spiked three weeks later at nearly 120,000 on 18 November, the day that Twitter staff began leaving of their own volition after being asked to subscribe to a new, "hardcore" work regimen.

The large numbers of people posting links to their Mastodon profiles coincided with the #RIPTwitter hashtag trending as users seemed to fear for the future of the platform. Despite bugs arising on Twitter as a result of big job losses among software engineers, the platform seems to be functioning relatively normally and the number of daily tweets has broadly stayed the same since Musk's takeover.

An analysis by Social Blade, a commercial analytics company, forecasts that Musk will become Twitter's most-followed user in mid-January 2023.

"Some 'thought leaders' immediately jumped onto Mastodon, but most users are 'laggards'"

"A lot of people have said they're quitting Twitter," says Emiliano De Cristofaro at University College London. "There has been an increase in users on Mastodon, but it's unclear if they're actually active users or just created an account and messed around a bit."

Bin Zia says the researchers hope to investigate how many new Mastodon users maintain their accounts. ▮

For more on Twitter, read Annalee Newitz's column on page 24

Zoology

Ant pupae produce a liquid eaten by larvae and adults

A NUTRIENT-RICH liquid produced by at least five ant species while in their pupal stage is consumed by the adult insects and larvae, and appears to nourish the latter. The same may be true in all ant species.

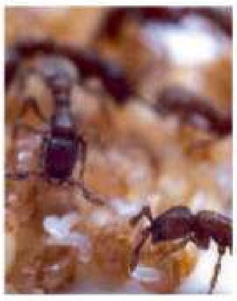
Orli Snir at the Rockefeller University in New York discovered that clonal raider ant (*Ooceraea biroi*) pupae secrete a liquid about six days before they hatch.

Alongside her colleagues, Snir then found that if the liquid built up, it led to a fungal infection and the death of pupae.

When the fluid was removed, the pupae grew as expected. This may mean they rely on adult ants and larvae to remove it, says co-author Daniel Kronauer at the Rockefeller University.

The researchers wanted to observe this phenomenon in a real-world setting to ensure that the liquid wasn't being secreted due to something in the laboratory interfering with pupal development.

To do this, they injected a dye into the pupae's exuvial space while they were in their colony. This space is a gap between the old and new exoskeleton of a pupa that forms as it is moulting. Within 24 hours, the larvae and adult ants in the colony had taken up the dye into their digestive tracts.



DANIEL KRONAUER

A nest of *Ooceraea biroi* clonal raider ants

Next, the researchers tested what effect the liquid had on larvae. Those deprived of it had stunted growth and lower survival rates (*Nature*, doi.org/jpb8). The team is studying the liquid's effect on adult ants.

Finally, the researchers isolated the pupae of four other ant species and found that they all produced a similar fluid. "There are 15,000 ant species, so we can't say for sure, but so far it seems that all ants produce this liquid," says Kronauer.

"The fact that the authors show this newly discovered phenomenon is actually widespread among ants will lead to many researchers changing their way of thinking around the world," says Chris Reid at Macquarie University in Sydney, Australia. ▮

Jason Arunn Murugesu

Astronomy

Titan's glistening clouds

The James Webb Space Telescope has imaged Saturn's largest moon

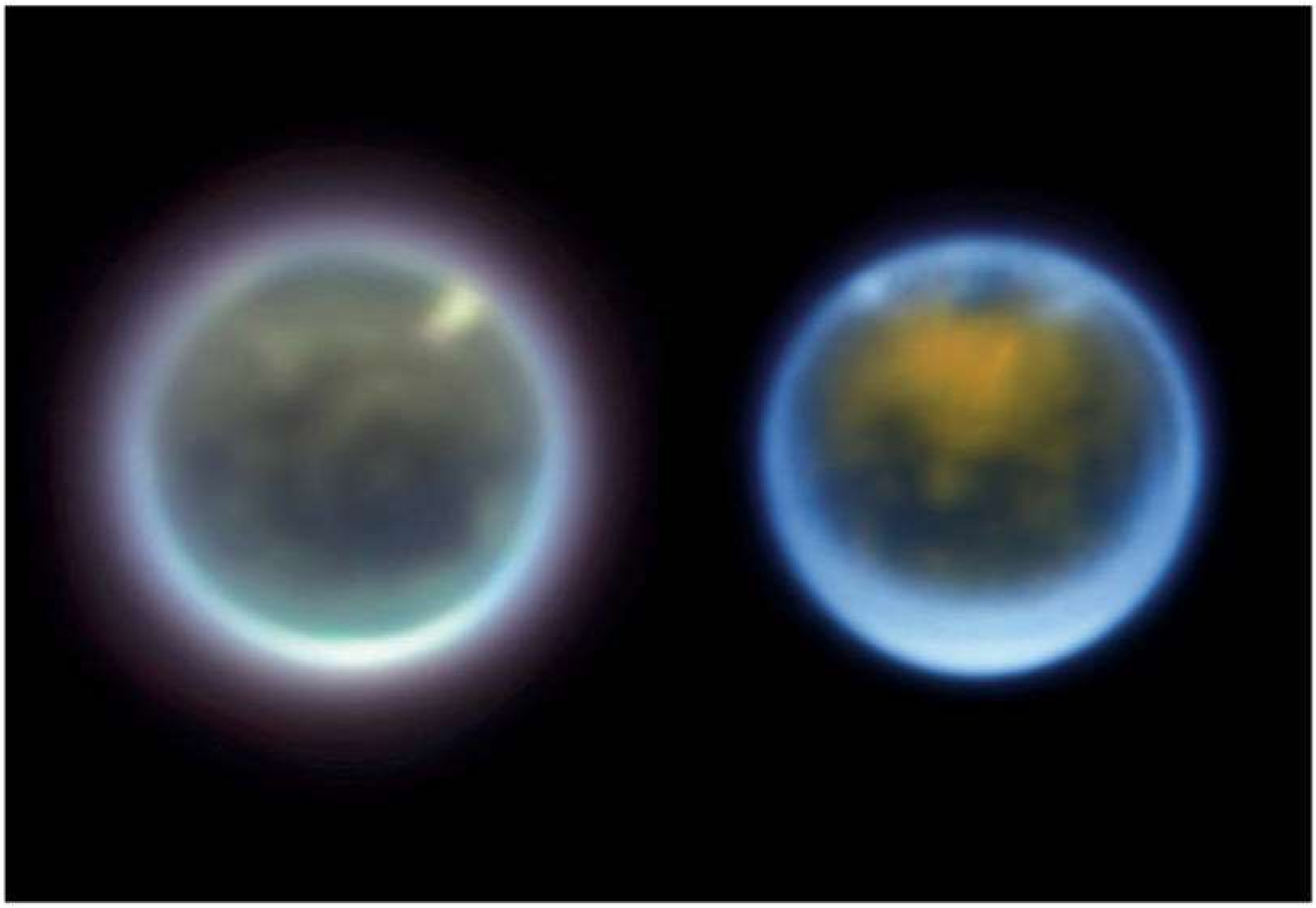
Leah Crane

THE James Webb Space Telescope (JWST) and the W. M. Keck Observatory in Hawaii have taken images revealing clouds floating across Titan, Saturn's largest moon.

The left image was taken by JWST. It is currently summertime in Titan's northern hemisphere, the time when clouds are expected to form most easily because of the increased sunshine on the surface.

In an effort to find out whether the clouds seen were moving, the JWST team reached out to the Keck Observatory and asked researchers to take follow-up observations. The image from Keck taken three days later is on the right.

"To our delight, there were clouds at the same positions, looking like they had changed in shape," said Imke de Pater at the University of California, Berkeley, in a statement. Delving deeper into the data should help researchers understand air circulation on Titan. ▮



NASA, ESA, CSA, JWST TITAN GTO TEAM, PAGAN (STSCI)/SCHMIDT

Technology

Famous paintings become mini masterpieces

MINIATURE versions of famous paintings, including *Mona Lisa* and *Girl with a Pearl Earring*, have been created using nanotechnology. Each is just a few millimetres across.

Ting Xu at Nanjing University in China and his colleagues made these minuscule masterpieces using nanostructures that manipulate the light rays that strike them, reflecting only specific colours, while suppressing all others.

The technique is inspired by insects such as butterflies whose intricate wing colour is created through structural means, rather than with pigment. It allows for better colour reproduction than paints or dyes, which don't work on these tiny scales, says Xu. "Their optical performance dramatically deteriorates once particle dimensions fall below the micrometre scale."

The researchers began by converting Leonardo da Vinci's *Mona Lisa* into pixels of specific colours. They then used a process called electron beam lithography to carve nanostructures, each designed to replicate the colour of one pixel, into silicon.

Finally, the researchers transferred this material to a silver film, just 200 nanometres thick, using adhesive tape. This silver backing helps reflect light through the nanostructures, creating the colours (*Nature Nanotechnology*, doi.org/jpn6).

Y. LU, TING XU, ET AL

***Mona Lisa*, recreated using nanotechnology at millimetre scale**

The team also replicated Johannes Vermeer's *Girl with a Pearl Earring* and da Vinci's *Virgin of the Rocks* using the same technique. Xu says that apart from some slight differences in certain colours between the nanoscale versions and the real artworks, the reproductions are largely identical.

The technology could one day be used in anti-counterfeiting efforts, says Xu. "We can print our information-patterned nanostructures in some important currency or luxury goods," he says. ▮

Jason Arunn Murugesu

Geology

Yellowstone supervolcano is stuffed with magma

James Dinneen

THE magma reservoir beneath the Yellowstone Caldera in Wyoming contains almost twice as much melted rock as previously thought. The increase, however, doesn't meet the threshold to make an eruption at Yellowstone more likely.

The Yellowstone Caldera in north-western Wyoming is one of the largest volcanoes in the world. In the past 2.1 million years, it has seen three catastrophic eruptions that covered North America in ash.

Eruptions are supplied with magma from two huge reservoirs beneath the caldera, one near the mantle and one a few kilometres below the surface. The reservoirs contain a complex "crystal mush" of melted rock and crystals, says Ross Maguire at the University of Illinois Urbana-Champaign. The composition of this mush partly determines the volcano's likelihood of erupting: a higher proportion of melted rock to solid crystals makes the magma more likely to mobilise.

Because seismic waves move more slowly through areas with more melted rock, Maguire and his colleagues were able to analyse seismic data recorded around Yellowstone over the past 20 years to estimate the proportion of melted rock in the shallower magma reservoir.

They found the reservoir is composed of 16 to 20 per cent melted rock on average – compared with a previous estimate of about 9 per cent – depending on the shape of spaces between solid crystals. That suggests the reservoir contains about 1600 cubic kilometres of melted rock, or almost twice as much as the previous estimate of roughly 900 cubic kilometres (*Science*, doi.org/jpcr).

Even at the high end of their estimate, Maguire says the proportion of melted rock is still well below the 35 to 50 per cent threshold needed for an eruption. ▮

Analysis Coronavirus

China's failure to vaccinate makes giving up on zero covid a huge risk

The country has eased some lockdown restrictions, which could lead to millions of older people dying, reports **Michael Le Page**

IN RESPONSE to protests in many parts of the country, the Chinese government is easing some of the draconian lockdowns it imposed to prevent the spread of the coronavirus. But its failure to vaccinate the most vulnerable people means that the relaxation of restrictions risks causing a vast number of deaths.

A big wave of infections in the country could lead to between 1.3 million and 2.1 million deaths, according to UK science analytics company Airfinity. It has modelled what could happen across China based on what happened in Hong Kong in March this year.

"A wave of infections could be devastating," says Matt Linley at Airfinity.

Most countries have ended nearly all covid-19 measures without a big surge in deaths, although in the US and Europe there is about one death from covid-19 per million people each day. Deaths remain relatively low because of high levels of immunity from vaccination and infection, and also because many of the most vulnerable people have already died.

New Zealand saw death rates rise as its zero-covid policy came to an end. However, thanks to vaccination rates of more than 90 per cent in those aged over 60, it had no sudden peak, despite the lack of previous exposure to the virus. Since the pandemic's start, about 430 people per million are reported to have died of covid-19 in New Zealand, compared with 3200 per million in the US and UK.

2.1m

Number of deaths a big wave of covid-19 could cause in China

In Hong Kong, by contrast, there was a big spike in deaths when its efforts to maintain zero covid ended in March. The main reason was that only around 30 per cent of those aged over 80 were vaccinated. Hospitals were also overwhelmed by the number of cases, meaning some people died because they didn't get the usual standard of care.

There have now been 1430 reported covid-19 deaths per million people in Hong Kong. That is about half the number in the US and UK, and more than three times that in New Zealand.

According to Airfinity, death rates across mainland China could be even higher than in Hong Kong, for several reasons. "Only 40 per cent of over 80s have had a booster, with the majority getting that nearly a year ago," says Linley. Models that take into account the waning of immunity over time suggest that protection levels have now fallen well below those in Hong Kong in March, he says.

What's more, mainland China has half as many critical care beds per person as Hong Kong, says Linley. "So a wave of infections could have a dramatic impact on mortality once hospitals are at capacity." As a result, a major wave across China could result in up to 1500 deaths per million people, Airfinity's models suggest, or 2.1 million in total.

One apparently official estimate is lower. An article released by the Communist party committee in Zhejiang province reportedly warns there could be 600,000 deaths in those aged over 60 if all restrictions are lifted, or around 400 per million people.

Health officials in China are well aware of the situation. "The outbreak in Hong Kong is a particularly profound lesson for us, an example that if the vaccination rate for the elderly is low, the rate of severe cases and deaths will be high," said Wang Hesheng at the National Health Commission in China in March.

Despite this, China continued to focus on zero covid regardless of the economic and humanitarian cost. It has belatedly announced a plan to ramp up vaccination of older people, but this could take months. Now, the easing of restrictions – with the country reporting tens of thousands of cases per day – could lead to the outbreak worsening, forcing the authorities to choose between a big wave of deaths or reimposing draconian measures. ▮

Protests against lockdowns in Beijing, China, on 28 November

BLOOMBERG/GETTY IMAGES

Health

Reviving Neanderthal antibiotics

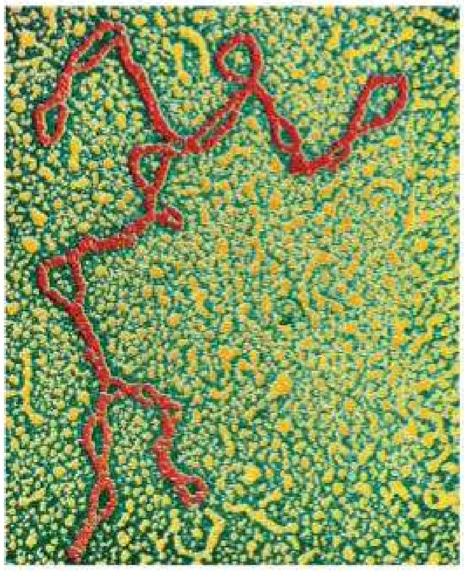
Exploring the DNA of archaic humans could help bring back extinct, bacteria-killing proteins

Carissa Wong

REVIVING extinct antibiotic molecules encoded in the DNA of ancient humans could provide a new weapon in the fight against antimicrobial resistance.

Last year, César de la Fuente at the University of Pennsylvania and his colleagues reported on more than 2000 antibiotic peptides encoded by modern human DNA. Now, de la Fuente and many of the same team have identified six more antibiotic peptides encoded in ancient DNA that comes from the energy-making mitochondria in the cells of Neanderthals and Denisovans.

“We’ve always dreamed of bringing back extinct organisms like the dinosaurs, as in *Jurassic Park*. But, of course, that has a lot of ethical, ecological and technical problems,” says de la Fuente. “Instead of bringing back entire organisms, we thought, could we bring back molecules from the past that could help with problems like antibiotic resistance we see today?”



ALAIN POL, ISM/SCIENCE PHOTO LIBRARY

Mitochondrial DNA (red) can encode bacteria-killing proteins

De la Fuente and his colleagues created an AI that simulates how enzymes called proteases would cleave proteins, encoded by ancient DNA, into fragments known as peptides. They ranked 69 ancient peptides that the AI identified based on their predicted antimicrobial activity by assessing molecular properties such as positive or negative charge.

“When you get infected, there might be proteases that increase or decrease in levels in different areas of the body, and that could cleave proteins to produce fragments that operate as antimicrobials – essentially serving as part of the immune system,” says de la Fuente.

The researchers ordered the 69 peptides from a firm that can manufacture them from the DNA sequences. Adding the molecules to Petri dishes containing bacteria revealed six previously unknown antibiotic ones.

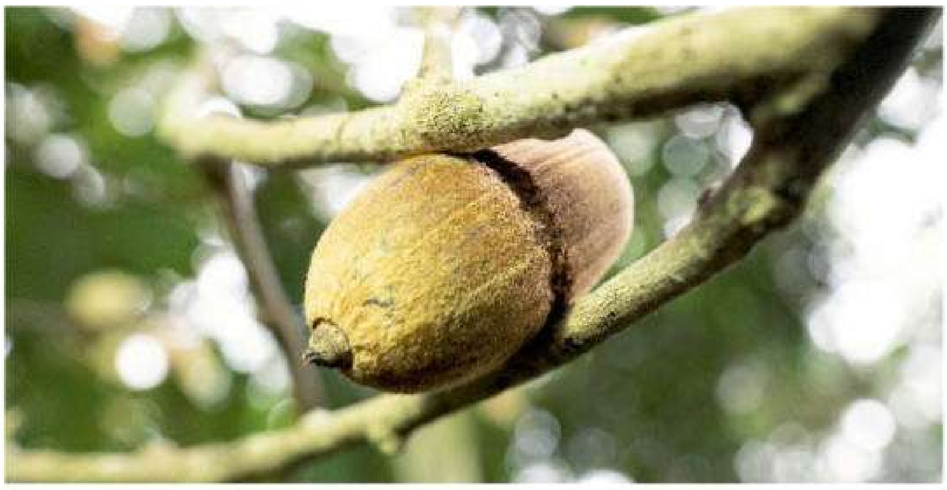
Three came from Neanderthals and three from Denisovans, and each worked against at least one species of bacteria. One of the Neanderthal peptides could destroy methicillin-resistant *Staphylococcus aureus*, or MRSA, known as a superbug because it is resistant to some antibiotics. The ancient antibiotics also reduced bacterial levels in skin infections in mice (bioRxiv, doi.org/jn7h).

> **“Instead of bringing back organisms, we thought, could we bring back molecules from the past?”**

Further research will be needed to check if they would be safe to use, says de la Fuente. “We think evolution is a great filter of things that work and things that are going to be safe and effective. By mining from ancient organisms, we probably will have to worry about safety less than designing drugs from scratch.” ▮

Zoology

Flying squirrels use carving skills to store nuts in trees



QINWENHAO

A nut with a groove chewed around it and wedged in branches on Hainan Island

TWO species of flying squirrel living in the tropical rainforests of Hainan Island off China carve grooves around nuts so they can wedge the food in the forks of twigs.

Suqin Fang at Sun Yat-sen University in Guangzhou, China, says one of these species may have learned the behaviour from watching the other, although this is hard to establish. If this did happen, it would be the first known example of an animal culture being transmitted between species.

Some squirrels in the tropics hang clusters of nuts over tree branches rather than burying them, probably because buried nuts rapidly germinate or decompose in warm, wet conditions. Storing individual nuts in trees is trickier because they typically have rounded shapes.

In 2005, when team member Han Xu at the Chinese Academy of Forestry went to study plants in the tropical rainforests on Hainan, he was intrigued to see nuts in the forks between twigs. The nuts stay in place even if the branches are shaken because the twigs fit into a groove chewed in a circle around the middle of the usually acorn-shaped nuts.

Local people have known about this behaviour for a long time, says Fang, but there have been no scientific reports about it until now.

The team documented about 150 stored nuts in a 5-hectare area of forest (bioRxiv, doi.org/jpbk). They then set up 32 infrared cameras to monitor some of the stored nuts. They found two species of squirrel came to check the nuts or retrieve them: a subspecies of the Hainan flying squirrel called *Hylopetes phayrei electilis* and the particoloured flying squirrel (*Hylopetes alboniger*).

The videos don’t show the initial carving and placement of the nuts. But while checking nuts, the animals sometimes refine the grooves to improve the fit, says Fang. ▮

Michael Le Page

Health

Sperm-blocking gel could work as a contraceptive

Alice Klein

A GEL that is applied inside the vagina has been shown to block sperm injected into female sheep and may provide an alternative to hormonal contraceptives for people.

Hormone-based birth control methods, like the contraceptive pill and hormonal intrauterine devices, are highly effective but can cause side effects, including headaches, mood changes and sore breasts.

Non-hormonal methods like condoms and fertility tracking apps don't have these side effects, but tend to be less reliable.

Now, Ulrike Schimpf at KTH Royal Institute of Technology in Sweden and her colleagues have developed a vaginal gel that may work as well as hormonal contraceptives, but without the side effects.

The gel contains chitosan, a biopolymer derived from fungus or crab shells. The chitosan forms cross links with proteins that are secreted in cervical mucus. This thickens the mucus so that it blocks sperm from getting past the cervix and into the fallopian tubes, where egg fertilisation occurs.

The researchers inserted the gel towards the backs of the vaginas of sheep, which are similar to those in humans. An hour later, they artificially inseminated each of the eight sheep tested with 1 billion sperm. The gel was found to spread throughout the vagina and into the entrance of the cervix. It formed an effective barrier, with sperm managing to get past the cervix of only one of the sheep, and in that case it was just two of the 1 billion sperm (*Science Translational Medicine*, doi.org/grcqxv).

The researchers plan more sheep studies to test if the barrier stays intact during sexual intercourse and prevents pregnancies. Trials in people would also be needed to determine how long before sex the gel should be inserted and how long any protection would last. ▮

Environment

Volcanic eruption shut down key climate observatory

James Dinneen

SIMON FRASER/MAUNA LOA OBSERVATORY/SPL

The Mauna Loa atmospheric research station

THE lava flow from the ongoing eruption of the Mauna Loa volcano in Hawaii has knocked out power and cut access to an observatory that has recorded the concentration of carbon dioxide in the atmosphere since 1958.

Mauna Loa started erupting on the evening of 27 November. Initially, the lava was confined to the volcano's summit caldera, but on 28 November the Northeast Rift Zone – a section on the side of the volcano where the surface can crack and split – also started erupting. This caused lava to flow upslope of the Mauna Loa Observatory, according to the US Geological Survey.

At 6.30pm local time on 28 November, instruments at the observatory lost power, according to a statement from the University of California, San Diego. The observatory is run by the National Oceanic and Atmospheric Administration (NOAA) and hosts instruments measuring changes in the atmosphere, including the flux of greenhouse gases.

Without power, these instruments stopped working. For instruments that measure the concentration of CO_2 in the atmosphere, it was the first time they stopped keeping records since 1984, when the last eruption of Mauna Loa knocked out power for a month. The observatory itself doesn't appear to be threatened by the lava.

Researchers are now considering ways to relocate the equipment to continue measurements, says Ralph Keeling, an atmospheric scientist at the Scripps Institution of Oceanography. "It's not the end of the record," he says. "It's a gap that I hope we can fill." He says restoring power and access to the observatory may take months.

Many other sites around the world now collect data on atmospheric carbon, but the record at Mauna Loa is unique. "It's the longest continuous detailed record," says Keeling. Even short gaps in the data set can reduce its value, he says.

It is also of historic importance to climate science. Observations of atmospheric CO_2 taken at the observatory produced the famous upward trend known as the Keeling Curve, named after the researcher Charles David Keeling – father of Ralph Keeling – who conducted the research. This record, along with measurements from the South Pole, contributed the first clear evidence that rising levels of atmospheric CO2 were driven by the burning of fossil fuels.

1958

Year CO_2 measurements began at Mauna Loa Observatory

The observatory was located on Mauna Loa to ensure measurements weren't affected by local changes to CO_2, such as emissions from cars or cities. The lack of plants on the volcanic rock meant records also wouldn't be affected by the respiration of nearby vegetation. The observatory has made measurements of the concentration of atmospheric CO_2 since 1958, nearly uninterrupted other than a period of a few months in the 1960s when operations stopped due to federal budget cuts, and during the 1984 eruption of Mauna Loa.

Charles David Keeling's first measurement at the observatory in March 1958 recorded an atmospheric concentration of CO_2 of 313 parts per million. In 2021, average atmospheric concentration of CO_2 reached a record 415.5 parts per million and has continued to rise through 2022. ▮

Palaeontology

Ancient skull rewrites the story of bird evolution

Christa Lesté-Lasserre

A reconstruction of a key fossil in a stone found in Belgium

A 67-MILLION-YEAR-OLD skull has overturned an established theory about how modern birds evolved.

Most birds today can move their upper beaks, but the flightless group that includes ostriches and emus, also known as ratites, can't – a feature that, for 155 years, has been considered primitive. The discovery of a jointed upper beak in a bird from the dinosaur age, however, suggests the early ancestor of all modern birds may have had a jaw that looked more like that of a turkey than an ostrich, says Daniel Field at the University of Cambridge.

"The assumption that ostriches, rheas, emus and kiwis somehow retain features that are indicative of what the ancestor of modern birds might have been like – I think that's actually just not right," he says. "I always assumed that it was, but I don't buy it any more."

In 1867, biologist Thomas Henry Huxley proposed that birds with fused upper beaks had maintained this trait from ancient ancestors, and that jointed upper beaks – which allow the top beak to move up and down independently of the head – evolved later.

Approximately 99 per cent of modern birds have jointed upper beaks, which may have advantages for nest building, grooming, food gathering and defence, says Field.

About 20 years ago, researchers at the Natural History Museum of Maastricht, in the Netherlands, analysed a fossil partially encased in stone found by a collector near Liège, Belgium. The team identified one of the protruding bones as a shoulder bone and believed that there were skull bones trapped inside the stone.

In 2020, Juan Benito, also at the University of Cambridge, took another look at that so-called shoulder bone and thought it looked strange. He contacted Field and together they created 3D scans of that and another protruding bone that seemed to be mislabelled.

To their amazement, the two bone pieces matched up perfectly along their fragmented lines. Combined, they created a single bone that looked like the jointed upper beak bone of most modern birds, called the pterygoid.

Comparisons of their scans with those of 34 other fossilised birds and dozens of modern birds confirmed the bone's identity and suggested that, like most modern birds, such as turkeys and ducks, this ancient bird could lift its upper beak (*Nature*, doi.org/jn6c).

The team named it *Janavis finalidens,* for Janus, the Roman god of beginnings and endings, and for the Latin words *avis*, *finalis* and *dens*, which mean bird, final and teeth. *J. finalidens* was one of the last known toothed birds, which are suspected to have died out during the mass extinction of dinosaurs 66 million years ago.

The findings suggest that, surprisingly, ostriches and their relatives must have evolved a fused beak later, says Lawrence Witmer at Ohio University. "We always thought the palatal structure of ratites was primitive and dinosaur-like," he says. "This new study is a remarkable example of how just a few key fossil remains – analysed with a keen eye – can overturn some long-standing and cherished notions." ▮

Artist's impression of the toothed bird, *Janavis finalidens*

DR JUAN BENITO AND DR DANIEL FIELD/ UNIVERSITY OF CAMBRIDGE, PHILLIP KRZEMINSKI

Health

Drug clears sleeping sickness parasite from the body

Jason Arunn Murugesu

A SINGLE pill was 100 per cent effective at clearing the parasite responsible for sleeping sickness among people with an early-to-intermediate infection. It was even 95 per cent effective when the parasite may have spread to the brain, indicating an advanced infection.

Sleeping sickness, also known as African trypanosomiasis, is mainly treated via the drug fexinidazole. Although up to 91 per cent effective, fexinidazole must be taken once a day for 10 days under medical supervision.

To test the potential of a one-off drug called acoziborole, Anthoine Tarral at the Drugs for Neglected Diseases initiative in Switzerland and his colleagues recruited 208 people who had the condition in the Democratic Republic of the Congo and Guinea. More than three-quarters of the participants were given acoziborole while in a late stage of the infection, defined as the sleeping sickness parasite being in their cerebrospinal fluid, suggesting that the infection may have reached their brain. The remaining participants were treated when the parasite was in other bodily fluids, but not their cerebrospinal fluid.

Among the participants with late-stage sleeping sickness, acoziborole had a 95 per cent success rate, defined as no parasite being found in various bodily fluids at 18 months post-treatment (*The Lancet Infectious Diseases*, doi.org/jn4j). This rose to 100 per cent among those with an early-to-intermediate infection.

"This drug can change the world of this disease," says Tarral. Acoziborole could be available in two years, he says.

"The findings show acoziborole to be a safe, effective oral therapy for the treatment of human African trypanosomiasis," says David Horn at the University of Dundee, UK. ▮

Quantum physics

Wormhole in a quantum computer

Researchers sent a message through a simulated wormhole using quantum entanglement

Leah Crane

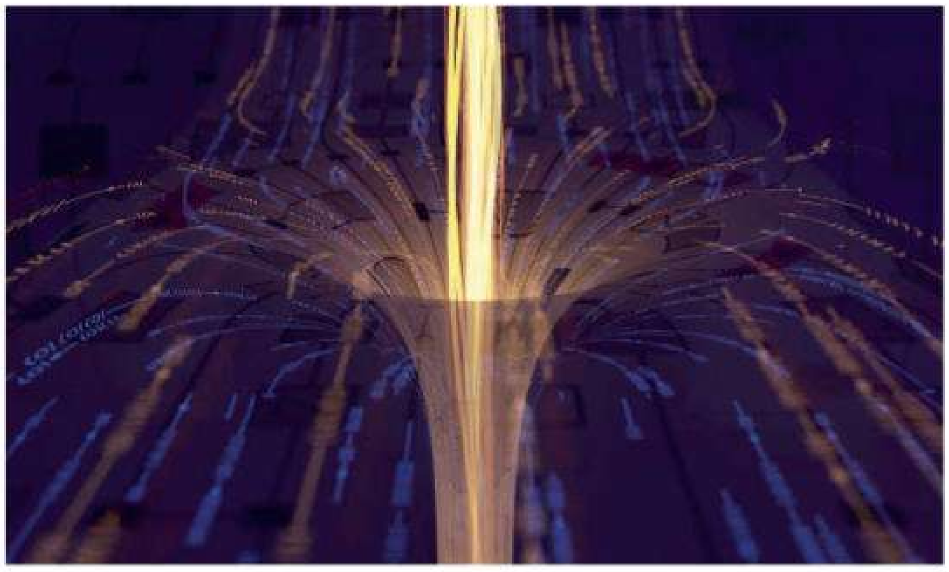
A QUANTUM computer has been used to simulate a holographic wormhole for the first time. In this case, the word "holographic" indicates a way to simplify physics problems involving both quantum mechanics and gravity, not a literal hologram. Simulations like this could help us understand how to combine those two concepts into a theory of quantum gravity – perhaps the toughest and most important problem in physics.

Both quantum mechanics, which governs the very small, and general relativity, which describes gravity and the very large, are extraordinarily successful in their respective realms, but these two fundamental theories don't fit together. This incompatibility is particularly apparent in areas where both theories should apply, such as in and around black holes.

Holography allows physicists to create an equivalent of these tremendously complicated areas, similar to how a 2D hologram can show 3D details. Maria Spiropulu at the California Institute of Technology and her colleagues used Google's Sycamore quantum computer to simulate a holographic wormhole – a tunnel through space-time with black holes at either end. They simulated a type of wormhole through which a message could theoretically pass, and examined the process by which it could make that journey.

In a real wormhole, the journey would be largely mediated by gravity, but the holographic wormhole instead uses quantum effects, removing relativity from the equation. So, when the message passes through the wormhole, it undergoes quantum teleportation, a process by which information about quantum states can be sent between two distant but quantum-entangled particles. For this simulation, the "message" was a signal containing a quantum state – a quantum bit in a so-called superposition of both 1 and 0 (*Nature*, doi.org/jn5v).

Information going through a wormhole is scrambled and then reassembled



INQNET/A. MUELLER (CALTECH)

"The signal scrambles, it becomes mush, it becomes chaos, and then it gets put back together and appears immaculate on the other side," says Spiropulu. "Even on this tiny system, we could prop up the wormhole and observe just what we expected." This occurs because of the entanglement between the two black holes, which allows the information going in one end of the wormhole to be preserved at the other end.

The simulation used only nine quantum bits, or qubits, so it was very low-resolution. It had the same general shape as the object it represented – like a picture of a bird taken from far away – but it had to be carefully adjusted to display the characteristics of a wormhole. "If you want to see this as a wormhole, there are a number of parallels, but it's definitely a matter of interpretation," says Adam Brown at Stanford University in California.

Using a more powerful quantum computer could help bring the image into focus. "This is just a baby wormhole, a first step to test the theories of quantum gravity," says Spiropulu. ▮

Immunology

Vaccine protects mice against plague bacteria

AN EXPERIMENTAL vaccine protects mice from a lethal dose of the bacterium that causes the plague.

Famous for killing millions in Europe in the Middle Ages, the bacterium *Yersinia pestis* still causes deadly outbreaks. Vaccines containing live or dead *Y. pestis* have been used in the past, but they have drawbacks, such as short-lived immunity and serious side effects.

Now, Dan Peer at Tel Aviv University in Israel and his colleagues have developed a plague vaccine containing the bacterium's genetic code in the form of mRNA. The mRNA in the vaccine encodes a protein found on the surface of *Y. pestis*. When a person receives an mRNA vaccine, their cells take up the mRNA and produce the protein, which lets their immune system learn to recognise it.

The team injected 12 mice with three vaccine doses and 12 mice with a dummy vaccine coding for a non-plague protein. The mice were then exposed to a dose of *Y. pestis* that is normally lethal. All of the mice given the plague vaccine were alive after 20 days, when the experiment ended, whereas all the mice given the dummy vaccine died within a week.

By analysing blood samples from the mice, the team found the vaccine generated two types of immune responses: antibodies – small molecules that can stop bacteria entering cells – and T-cells, which can kill infected cells.

"It is unclear how long the vaccine's protection lasts and whether the findings will translate to people"

"This is the first demonstration of a fully protective mRNA vaccine against a lethal bacterial pathogen [that lives outside host cells]," said Peer in a presentation at the 10th International mRNA Health Conference in Boston last month.

"It is really exciting to see that this novel mRNA-based plague vaccine gave full protection against bubonic plague in a mouse model," says Jr-Shiuan Lin at the National Taiwan University in Taipei. It is unclear how long the protection lasts and if the findings in mice will translate to people, says Lin. ▮

Carissa Wong

Dementia

Questions over Alzheimer's drug

Lecanemab slows cognitive decline, but its benefits may not outweigh its potential risks

Grace Wade

A DRUG called lecanemab is the first treatment that slows cognitive decline in people with early Alzheimer's disease. It also decreases plaques and tangles in the brain that are thought to drive the condition's progression.

While it may sound promising, some question whether these effects will have a meaningful impact on Alzheimer's symptoms.

Potential concerns have also been raised about the drug's safety. During an 18-month study made up of almost 1800 people with early Alzheimer's disease, 0.7 per cent of those who received lecanemab died, compared with 0.8 per cent of those having placebo infusions.

In a statement released on 30 November, the Japan-based pharmaceutical firm Eisai, which developed lecanemab, said that none of these deaths was related to the drug. In October, however, *STAT* reported that lecanemab may have contributed to one participant's death. On 27 November, *Science* reported that a second participant died from a brain haemorrhage that some researchers linked to lecanemab.

Eisai told *Science* it couldn't comment on individual cases, but said that "all the available safety information indicates that lecanemab therapy is not associated with an increased risk of death overall or from any specific cause".

Nevertheless, the reports prompted some to ask if lecanemab's benefits outweigh any risks, a question raised by *New Scientist* when preliminary results were released in late September.

Lecanemab removes clumps of protein in the brain known as amyloid plaques. For decades, researchers have believed these drive Alzheimer's disease, yet many treatments that target them haven't shown benefits in trials.

In a late-stage trial, people aged 50 to 90 with early Alzheimer's disease received intravenous infusions of either lecanemab or a placebo once every two weeks for 18 months. All the participants had evidence of amyloid accumulations in their brain.

> "Some say the effect of the drug is so small, that maybe it's not worth it, given the potential risks"

Christopher van Dyck at Yale University and his colleagues measured the participants' cognitive function before the trial and then every three months up to month 18. This was assessed via interviews with the participants and their caregivers. The participants also completed questionnaires that gauged their quality of life before, during and after the study.

By the end of the trial, both groups showed signs of cognitive decline. However, this was 27 per cent slower in the lecanemab group, on average, compared with the control group (*NEJM*, doi.org/grcm47). This may seem fairly substantial, but the effect is quite small – a 0.45-point difference on a scale of 0 to 18.

"Most Alzheimer's experts feel that slowing this very bad disease by 20 to 30 per cent is meaningful to patients," said researcher Sharon Cohen, at the Toronto Memory Program in Canada, during a press conference held by Eisai in late November.

Brain changes

Lecanemab also appears to have a cumulative effect, said Cohen. Statistical modelling suggests that about two years of treatment could delay the condition's progression by up to three years.

When it came to quality of life, the control group reported about a 50 per cent greater reduction, on average, from the start to the end of the study, compared with the lecanemab group, according to results presented at the 2022 Clinical Trials on Alzheimer's Disease conference in San Francisco.

ANDREW BROOKES/IMAGE SOURCE/GETTY

Alzheimer's disease is linked to the build-up of proteins in the brain

About 400 participants also had brain scans to assess any changes to their amyloid plaques. Those treated with lecanemab had about a 70 per cent lower amyloid score, on average, from the start to the end of the trial. The control group's scores increased by almost 5 per cent, on average.

The lecanemab group also had substantial decreases in misfolded brain proteins called tau tangles, which increased in the control group. "Tau is the abnormal protein in Alzheimer's disease that has the best correlation with clinical decline," says Lea Grinberg at the University of California, San Francisco.

In addition to the previously reported patient deaths, the trial raised other safety concerns.

More than 17 per cent of people in the lecanemab group had some bleeding in the brain, compared with 9 per cent in the placebo group. In addition, almost 13 per cent of those given the drug had brain swelling and inflammation, compared with less than 2 per cent of those on placebo infusions.

"Some people say the effect of this drug is so small, that maybe it's not worth it, especially in people at high risk," says Grinberg.

In the 30 November press release, Eisai said: "The convergence of evidence across cognition and function, disease progression, health related quality of life, and caregiver burden demonstrate that lecanemab treatment may provide meaningful benefits to patients, their care partners, physicians and society." ▮

Space

Torn up star is one of brightest events ever

ASTRONOMERS have found the most distant known example of a star being eaten by a supermassive black hole and it is one of the brightest events ever seen.

When a star drifts too close to a supermassive black hole, it can be torn apart and swept into a disc surrounding the black hole. In February, researchers at the Palomar Observatory in California spotted such an event, naming it AT2022cmc. Follow-up observations revealed it took place 12.5 billion light years away from us (*Nature*, doi.org/jn6r, *Nature Astronomy*, doi.org/jn6q). "It's a new record," says Igor Andreoni at the University of Maryland.

The event was visible because the black hole fired out a jet of plasma and radiation at close to the speed of light directly towards us. **Jonathan O'Callaghan**

Environment

Bacterial risk from ocean microfibres

MICROFIBRES that pollute the seas are being colonised by bacteria that can cause food poisoning.

Microfibres are thin particles that are released when we wash clothes. Once they get into water systems, bacteria colonise them, making the fibres appear like food, so they get eaten and accumulate in the food chain.

Ana Luzia de Figueiredo Lacerda at Sorbonne University in Paris and her colleagues have identified the bacteria on microfibres in water samples from the Mediterranean Sea. Each fibre was home to more than 2600 bacterial cells, on average, from 195 species. One species, *Vibrio parahaemolyticus*, is a potential cause of gastrointestinal illness (*PLoS One*, doi.org/grcqw8).

Understanding the virulence of the bacteria will help us assess the risks microfibres pose to humans and the ecosystem. **Kismat Shrees**

JACOB BOCK/FAUNA & FLORA INTERNATIONAL

Conservation

Endangered gecko climbs back from the brink

A SPECIES of critically endangered gecko, which is brightly coloured and just 3 centimetres long, has nearly doubled in number since 2018, thanks to conservation efforts involving local residents.

The Union Island gecko (*Gonatodes daudini*) from Saint Vincent and the Grenadines was first scientifically described in 2005 and its small size and vivid colours quickly made it attractive to the illegal pet trade. This led to a fall in the wild population, which lives in a 50-hectare patch of ancient forest on Union Island.

So, in 2016, the Caribbean country's forest department plus conservation organisations worked with local residents to devise a species recovery plan.

This saw the local Union Island Environmental Alliance and international conservation charities Re:wild and Fauna and Flora International use a range of approaches, from the expansion and increased management of protected areas to anti-poaching patrols and round-the-clock camera surveillance by community wardens in the forest. As a result, the number of Union Island geckos has risen from 10,000 in 2018 to 18,000 today.

"As a Unionite and a community leader, I am extremely proud to be a part of this success story," said Roseman Adams, co-founder of the Union Island Environmental Alliance, in a statement.

The success in protecting the gecko has led the groups to develop a wider initiative that aims to protect other wildlife in the forest, providing sustainable employment and development opportunities for the local community in the process. **KS**

Really brief

YUSIK CHOI

Duck-like dino had streamlined body

Natovenator polydontus, a newly discovered dinosaur, is the first found to have a streamlined body like a diving bird, but that doesn't belong to the feathered class of dinosaurs that modern-day birds evolved from. It was semi-aquatic, looked a bit like a duck and ate meat (*Communications Biology*, doi.org/jpbh).

'Pac-Man' bot surfs around on ripples

A device 0.8 centimetres in size and shaped like Pac-Man can be steered across water by ripples. As it is a disc with a wedge cut out, ripples ricochet within its mouth-like opening, moving it. Adjusting the oscillation of the ripples changed its course, letting it avoid obstacles (arxiv.org/abs/2211.07495).

Powder removes plastics in water

A magnetic powder added to a soup of microplastics can absorb 100 per cent of the plastics within an hour. The powder is then sucked out using magnets, taking the polluting material with it. It could be used by water treatment plants to better remove such contaminants (*Chemical Engineering Journal*, doi.org/grchz4).

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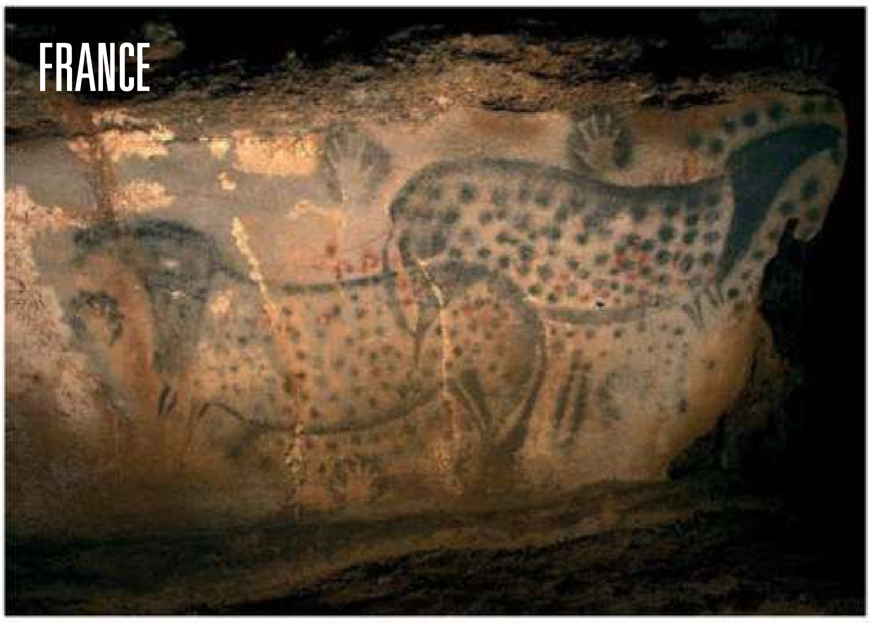

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Comment

Challenges of the deep

Links between marine sciences and commercial interests are a hangover from an imperial era that must end, says **Helen Scales**

ON 21 DECEMBER 1872, the converted warship HMS Challenger embarked from Portsmouth, England, on the first ever global scientific survey of the seas. Researchers from the Royal Society of London borrowed the vessel from the Royal Navy for a four-year, 130,000-kilometre voyage, which brought into focus the truly colossal scale of the global ocean and revealed vivid details of its living inhabitants.

Now, 150 years later, the Challenger expedition remains a milestone in oceanography. Scientists still use its enormous collections of marine organisms, including to study how the ocean is changing. Of course, much has altered since the Challenger set sail, not least the way science is done. Mapping the seabed used to require a lot of piano wire lowered over the side of boats to measure the depths, but is now done using beams of sound. Autonomous robots steer through the seas gathering data, while analysis of traces of DNA in water tell us which species are present. However, some old ideas from the Challenger era still linger and they urgently need to be left behind.

Back then, science wasn't driven simply by curiosity about the world and how it works, but by an imperialistic desire to find and secure access to resources. Exploration went hand in hand with exploitation – and this often continues today.

MICHELLE D'URBANO

It was Challenger scientists who first discovered metal-rich rocky nodules scattered across the abyssal sea floor. A meeting this September marking the 150th anniversary of the expedition was sponsored by the International Seabed Authority (ISA), a body established by the UN, with a keynote speech delivered by the organisation's secretary-general, Michael Lodge. At around the same time, the ISA gave the go-ahead for the first tests of a deep-sea mining operation that aims to exploit those same nodule fields.

The ISA is charged with facilitating deep-sea mining while ensuring the industry doesn't seriously harm marine life, a dual mandate that many consider to be conflicted and unworkable. The organisation has been criticised for accelerating mining plans amid concerns for the irreversible environmental impacts it could cause, as pressure grows from scientists, conservationists, governments and corporations for a deep-sea mining moratorium.

We know far more now than we did 150 years ago about the critical role the ocean plays as a support system for all life on Earth. It regulates the climate, generates oxygen, absorbs carbon and contains masses of biodiversity.

Meanwhile, industries are seeking to extract more than ever from the ocean, from seabed minerals to the fish that inhabit deep waters. Working closely with scientists not only shows industrialists what is there to exploit, and where, but it can also help legitimise their activities.

With the ocean facing so many threats, this is a critical time for marine science to move beyond the old narrative of exploitation and extractivism. In its place, we need a new model for seeking to better understand the ocean, to properly protect it and to find equitable, ethical and truly sustainable ways to use the vast blue parts of our planet.

An inspiring vision for what future ocean research could look like comes from the Challenger 150 programme. This global scientific cooperative isn't a single expedition, but combines the efforts of scientists worldwide on numerous research trips over the current decade. A major aim is to go to places scientists haven't been before, or not since the original Challenger expedition, and to use that knowledge to better appreciate how all of society benefits from the ocean.

Earth has one ocean, and we all depend on it – not just those who will gain the most commercially. ■

Helen Scales is a marine biologist and author of *The Brilliant Abyss*

This changes everything

What comes after Twitter? With the platform looking a little the worse for wear after its recent acquisition by Elon Musk, **Annalee Newitz** tries the best alternatives, so you don't have to

Annalee Newitz is a science journalist and author. Their latest novel is *The Future of Another Timeline* and they are the co-host of the Hugo-winning podcast *Our Opinions Are Correct*. You can follow them @annaleen and their website is **techsploitation.com**

EVEN if you have never glanced at Twitter, you have probably seen the news about its untimely fall from favour. Billionaire Elon Musk bought the platform, pledging to make it a free speech paradise in his copious spare time between launching rockets with SpaceX and making cars with Tesla. After mass firings and several bizarre management decisions, he is left with what insiders estimate to be 2000 to 3000 people running a system that previously required 7500 staffers and 5500 contractors. So it is looking a little the worse for wear. Features are breaking, the place is swarming with spambots and propaganda, and droves of users are leaving.

So where are former tweeters going? I decided to find out. I am one of the many longtime Twitter users who locked their accounts and left last month, and I went on a journey across the electronic ether to find a new home.

Mastodon looks a lot like Twitter and you can do Twittery things like follow other people and post short (500 characters or less) "toots" on your timeline. You can "boost" other people's toots and search for interesting topics. But unlike Twitter or Facebook, which are centrally controlled by a single company, Mastodon is made up of hundreds of loosely linked servers called instances that are run by volunteers. When you join Mastodon, you are actually joining one of these instances, which have names like Infosec.exchange (for computer security) and Astrodon.social (for astronomy).

Each instance has its own government, if you will, and its own rules. That is why Mastodon's world is called the "Fediverse" – it is like a group of federated tribes, and it is popular with scientists, journalists and academics.

How it improves on Twitter: no more viral garbage. It is hard for a post to get millions of random views within hours because the Fediverse model puts a bottleneck on information flow between instances. I find this appealing, because viral tweets often led to loss of context and nasty pile-ons. When you boost a toot on Mastodon, you can't add commentary to it either. This cuts down on "hate tweets", in which people retweet someone to get them pilloried by an online mob.

Another option is Hive Social. Created just three years ago by influencer Raluca Pop, it has been popular with Generation Z iPhone users for a while (the Android app is still pretty shaky). But as Twitter imploded, its user base ballooned to a million practically overnight. Hive looks and feels like a nice combination of Twitter and Instagram: you follow friends in a chronological stream, choosing to view posts as pictures or text. Press the beehive-shaped icon and you see posts from pals. Press the search icon and the app suggests posts based on interests you have chosen. (There is no algorithm that guesses what you like – it is all based on topics you picked.)

> **"Our future social media experience will be fragmented across platforms, so see which ones feel like home"**

A lot of creatives have flocked to Hive, so there is fun stuff to see. But with perhaps only three employees and a tiny amount of funding, the functionality and moderation are still nascent.

How it improves on Twitter: you aren't the product. Pop has promised that Hive will never have advertising and won't sell user data to make money. Her business model is based on in-app purchases. For a few bucks, you can get a cool song on your profile. As the app grows, users will be able to buy more things – thus making you a consumer of products, instead of being the product.

Then there is TikTok, a hyperactive stream of video almost entirely controlled by algorithm that is beloved of Gen Z and the young at heart. It is a place where you can watch tech how-tos, gawk at adorable kitties or see a new dance. You can post your own videos or search hashtags for topics you like. The app is clearly designed to be addictive and to foreground virality above all else. That means TikTok exacerbates many of Twitter's problems with virality and bullying.

How it improves on Twitter: it is just fun. It is much more visually entertaining, plus it is especially appealing to those under 25.

Finally comes Tumblr, which was all the rage 10 years ago. Since the Twitter meltdown, it is back in a big way. Join up and create a microblog, where you can post long essays, pictures or links. You can follow other people's blogs and have conversations in "notes" or "reblogs". Tumblr is popular with people in fandoms, from *Doctor Who* to romance novels.

How it improves on Twitter: you can write lengthy posts and have in-depth discussions that feel intimate. It is more like a book club than a crowded theatre.

For now, I am trying out all of these, though there are other options, from Instagram and Discord to Twitch and Slack. I think our future social media experiences will be fragmented across many platforms, and the best thing to do is try several and see which ones feel like home. ▮

Annalee's week

What I'm reading
Bethany Brookshire's funny, insightful Pests: How humans create animal villains, *which is about why rats and pigeons aren't as terrible as you thought.*

What I'm listening to
The new podcast If Books Could Kill, *which is a masterclass in debunking pseudoscience and fake history in the kinds of pop books you buy at airports.*

What I'm working on
Hanging out @annaleen@wandering.shop on Mastodon and @ghidorahnotweak on Hive Social.

This column appears monthly. Next week: our columnists look back at the year that was

CONFLICT APPEAL

MEDECINS SANS FRONTIERES
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HELP US DELIVER MEDICAL CARE BEYOND THE FRONTLINES

An MSF medic treats a patient onboard the medical train. Photograph © Andrii Ovod/MSF

CHRISTOPHER STOKES IS COORDINATING MSF'S MEDICAL WORK IN UKRAINE

23 October 2022

"On 10 October I had just left the train station in Dnipro, eastern Ukraine, when the car started shaking. A second later, we heard the blast from the first missile. By the time we reached the office, we'd felt four more shockwaves from strikes. Since then, there have been regular waves of bomb attacks targeting infrastructure and civilian areas.

We're now gearing up for the possibility that the electricity will go off across Ukraine as a result of these ongoing attacks. That will have drastic knock-on effects on hospitals, healthcare and people's lives. People are heading into winter with the risk there will be no electricity, heating or hot water.

We're doing our best to prepare. We're helping a number of hospitals near the frontline get ready. We're running mobile clinics in areas previously under Russian occupation where people have had no access to the medicines they need for months. MSF operates a specially designed medical train that evacuates patients from near the frontlines of the fighting to safer areas and we're looking at ways to keep that running, even if the electricity fails. It's been kitted out with an intensive care unit and inpatient carriages. To date, we've evacuated 1,851 patients in 60 trips, most of them suffering from blast injuries and shrapnel wounds.

Last weekend we carried one family on the train who needed to be evacuated from the war zone. They had returned to their home in Nikopol on 5 October after having fled the war months earlier. On 6 October, their house was hit by a shell. One of the daughters was badly injured and ultimately had to have both legs amputated. She was only six years old.

The Ukrainians are doing the bulk of the medical work in this war. Our role is about filling the gaps. With these latest attacks, people's medical needs are growing, and it's vital we are here."

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In conflicts around the world, MSF teams are working around the clock to treat trauma injuries, conduct surgeries and provide lifesaving medical care to the victims of bombings and indiscriminate attacks.

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Night life

Author **Erich Hoyt**
Publisher **Firefly Books**

DAZZLINGLY unusual, these images of marine creatures, comprising plankton and other organisms, illuminate a journey that happens every day under the cover of darkness – as detailed in the new book, *Planktonia: The nightly migration of the ocean's smallest creatures*, by researcher and conservationist Erich Hoyt

The subtitle refers to the daily underwater ascent undertaken by these tiny, drifting organisms to feed in shallower waters when the sun sets. This prompts predators such as fish and squid to follow in their wake, tempted by the promise of a taste of plankton. Aside from providing a snack, however, plankton are also globally important: they sustain all life in the ocean by maintaining food webs and producing oxygen and nutrients and many of them sequester carbon dioxide, so help to reduce the impacts of climate change.

Predators of the animal component of plankton, called zooplankton (shown at bottom left, illuminated by an underwater camera), include the tropical two wing flying fish (top left), the hairy goosefish (central of the smaller images) and the immortal jellyfish (top right). The latter is so named because of its regenerative ability, which may hold clues to human ageing. Despite what you see here, it is only a few millimetres in size.

The row of smaller images also shows a larval tripod fish (left), which is about 2 centimetres long, and an eel larva, nearly transparent at this early stage of its life. These are both zooplankton, says Hoyt, but "even the zooplankton are often hunting other zooplankton, so they're all predators in that sense". ▮

Gege Li

Editor's pick

Life, the universe and everything – in pictures

19 November, p 14

From Paul Whiteley, Bittaford, Devon, UK

There has been a lot of talk of using the power of AI to create unique images, including movies, but how about going a step further in all of this.

If, say, we had a 1-megapixel matrix, with three colours and 256 brightness levels possible per pixel, and gave it sequential inputs for every pixel and every variable, then, as each possibility was created, intelligible images would be produced from time to time out of the random noise.

This might produce every image it is possible to see – and lots that it isn't, such as randomly generated pictures of your grandparents at every age and from different directions, a clear picture of who shot JFK from the grassy knoll – and one with Nixon's face or yours – a blackboard with the formula for faster-than-light travel and, of course, hundreds of millions that are unintelligible.

My maths isn't great, but I estimate we could go through the entire sequence in about 10^{50} years with present technology, but an advanced civilisation might get that down to a few billion years.

The Titanic solution for stemming glacier melt

29 October, p 8

From Jim McHardy, Clydebank, West Dunbartonshire, UK

Building a curtain across the Jakobshavn glacier in Greenland – a suggestion to slow it melting – is estimated to take a minimum of 30 years and be expensive. A quick, albeit unsightly, fix would be to sink two or more large ships across the front of the glacier, which would block the influx of warmer water that is quickly melting the ice.

Plenty of ships are waiting to be scrapped, so the owners may pay to be rid of them. If necessary, filling the ships with rock would ensure they remain in place.

Depending on the depth, other ships could be gently sunk on top to block the current all the way to the surface. Calving icebergs would be held back by the temporary dam, hopefully protecting the glacier further.

Just cover Colorado river reservoirs in solar panels

26 November, p 40 (p 36 in US)

From Tony Quigley, Tunbridge Wells, Kent, UK

Your article sets out the need to reduce evaporation from reservoirs on the Colorado river. Is it possible to cover these with floating arrays of solar panels? Given that solar radiation poses the greatest risk of evaporation, these panels would significantly reduce the effect of the sun on the lakes and would, of course, be able to generate large amounts of electricity.

Look at pain was both brave and powerful

19 November, p 38

From Charles Heatley, Sheffield, UK

Graham Lawton's article on nociplastic pain, as part of your wider look at pain, was powerful, moving and, at the end, shocking. As a family doctor, I am aware of the misery of this condition, the lack of availability of effective treatment on the National Health Service and the misunderstanding of it among colleagues. It was bravely written by a highly effective writer. Thank you.

From Gerry Dangerfield, Brisbane, Australia

In your collection of articles on pain, I would have liked to have seen a reference to hypnosis. As a former psychologist, I experienced its dramatic improvement of pain, especially in good hypnotic subjects. There are even reported instances of its use to induce total anaesthesia for surgery.

From Tim Lewis, Landshipping, Pembrokeshire, UK

Your excellent articles on pain refer to the beneficial effects of placebo. Many clinical trials have compared the effect of placebo versus no treatment for a variety of conditions. A review of these, published in 2001 (*The New England Journal of Medicine*, doi.org/bcp58d), concluded that placebos have no significant clinical benefit.

From Pamela Manfield, The Narth, Monmouthshire, UK

When it comes to pain, we should acknowledge how exercise may help control it. After wrenching a knee, I read that exercise might help, and this proved to be the case. Without it, I could have been on painkillers for 15 years and would probably be immobile. Doctors need to consider alternatives to medication.

Events in the US weaken the West's call for rights

Leader, 12 November

From Sam Edge, Ringwood, Hampshire, UK

Your leader on the challenges of population change states that all countries should be educating women and respecting their rights. That is certainly true, but in the US, which claims to be an enlightened society, many states are in the process of rescinding reproductive rights.

It rather weakens the West's case when suggesting to other parts of the world that they improve women's rights, if one of the largest of "ours" is removing them.

Crops under solar is even better in the tropics

5 November, p 27

From David Green, Harpenden, Hertfordshire, UK

Michael Le Page mentions that crops can be grown under solar panels so that farmland used for solar energy isn't wasted. Indeed, there is great potential for this combined strategy in tropical countries, where rows of solar panels can cover half the field, providing shade for plants and supporting rainwater harvesting. While economic returns in the tropics can be high, financing has been a stumbling block.

Reasons why biofuels should have a role

Letters, 19 November

From Guy Cox, Sydney, Australia

I totally agree with Fred White that we should get as much energy as we can from solar panels, but in playing down the potential role of biofuels, he misses two important points.

Firstly, biofuel, once produced, is available day or night, rain or shine. Secondly, producing biofuel from algae rather than crop plants generates a much higher yield per hectare and, importantly, requires no agricultural land.

As has been pointed out many times in your pages, lithium is a scarce resource and we simply can't rely on it to meet our considerable backup energy needs by storing excess solar power in batteries. Uranium for fission seems to be getting more attention lately, but we have about 50 years of high-grade uranium ore left. That isn't going to see my grandchildren through.

There are two sensible energy sources, algal biofuel and "green" hydrogen. That is where our investment should go.

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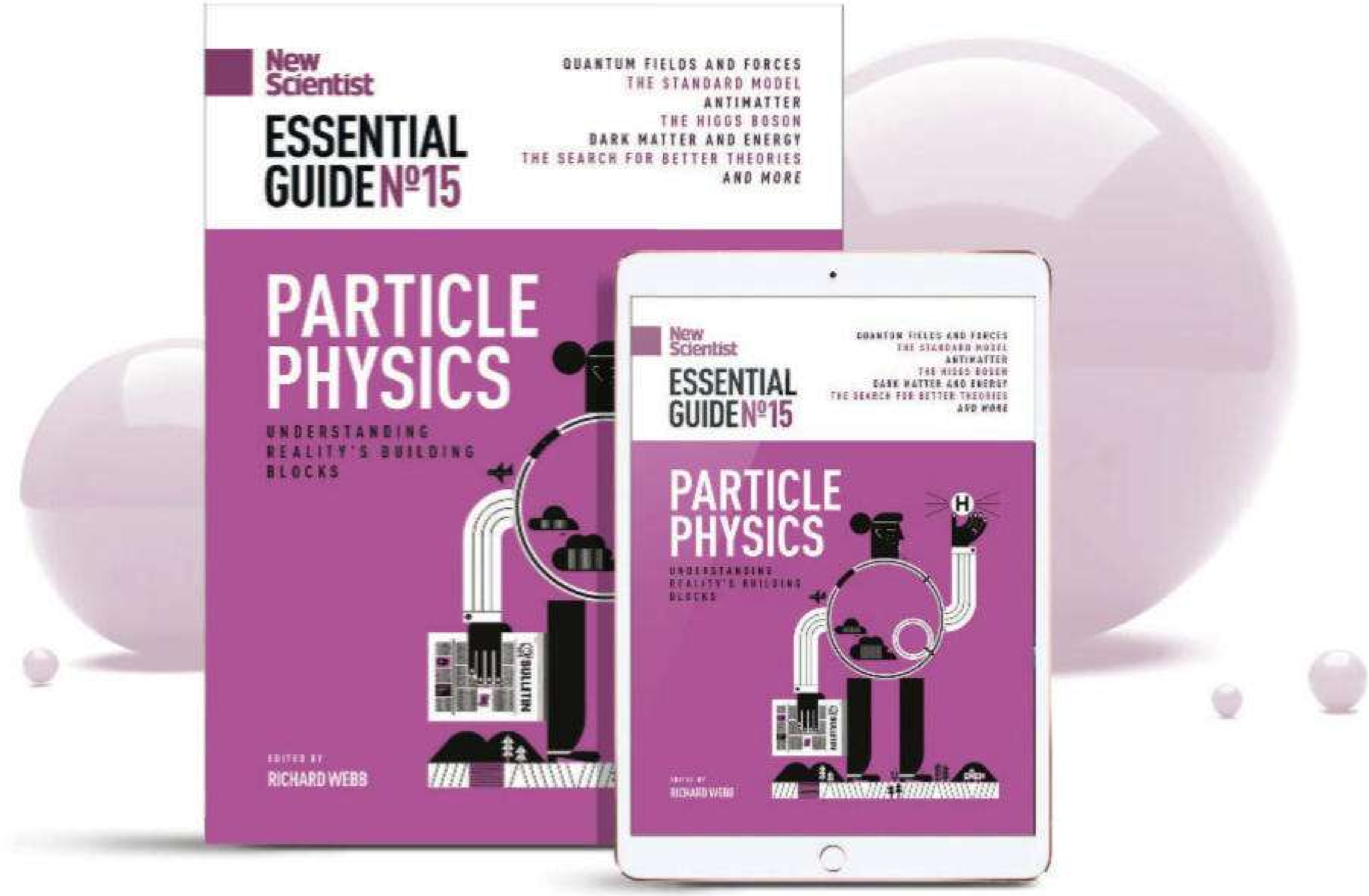

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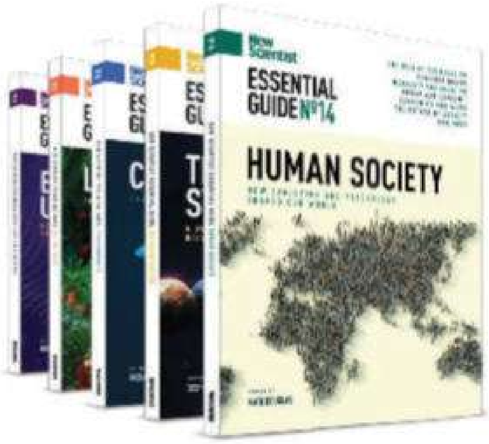
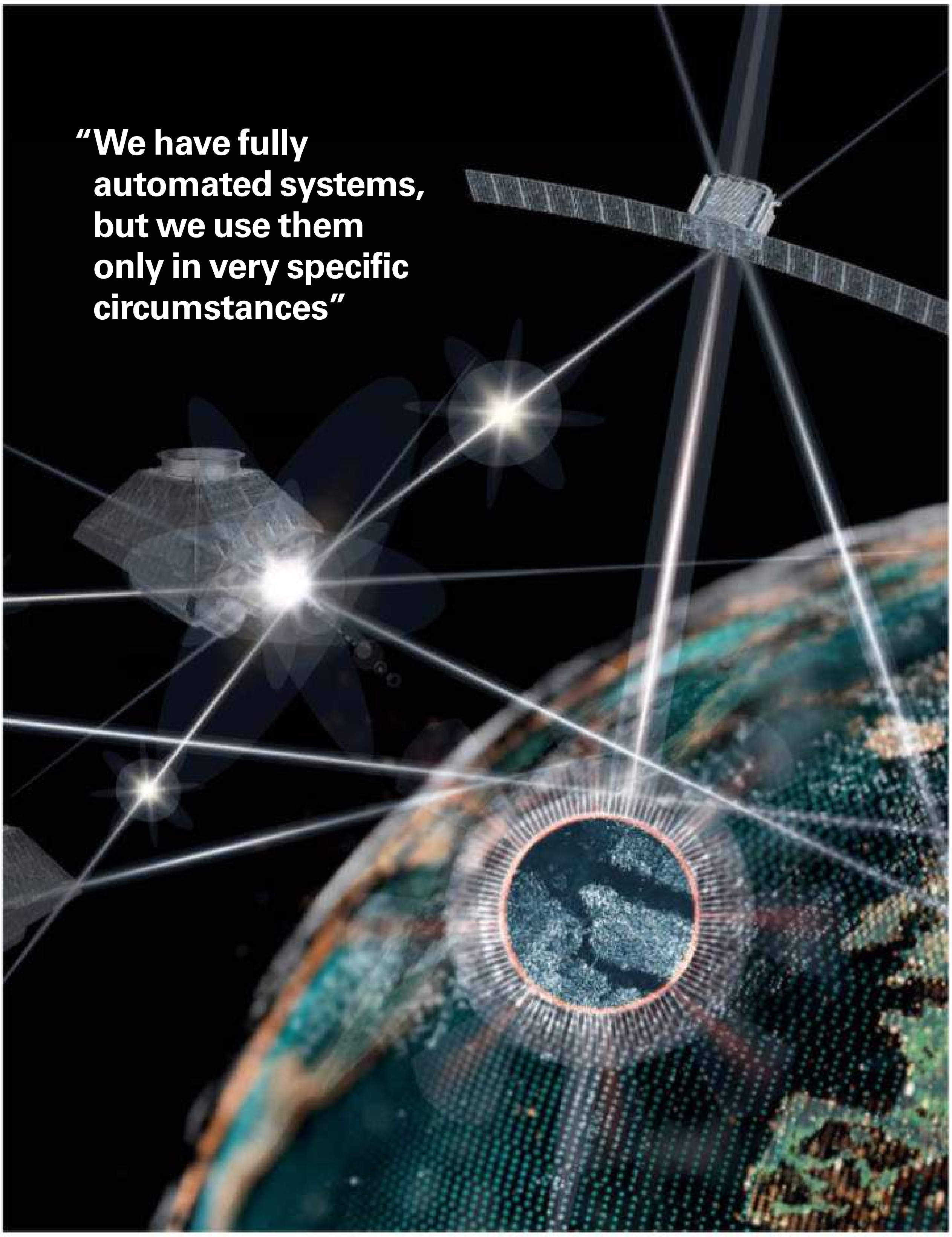


The future of conflict

Advanced technology, the war in Ukraine and the threat from climate change are shaping the future of warfare. So *New Scientist* invited a group of experts to discuss the emerging issues



“We have fully automated systems, but we use them only in very specific circumstances”

The landscape of conflict is changing. Reports from 21st century war zones describe localised conflicts with global implications in terms of food and energy supplies, displacement of populations and multi-nation involvement.

What’s more, advanced technologies, including autonomous systems and space-based information-gathering, are raising new dilemmas about how these can and should be deployed. Add this to the growing impact of climate change — itself often a spark for conflict — and it is clear that conventional thinking about conflict is undergoing a profound change.

New Scientist recently explored this new thinking in a debate on the Future of Conflict, sponsored by BAE Systems. A panel of experts discussed the implications of drones, artificial intelligence and automated decision-making, the evergreen importance of information, and the military’s response to the rapidly-changing climate.

Lieutenant General Tom Copinger-Symes, Deputy Commander of UK Strategic Command, sees a major shift happening in the way we look at military capabilities. It used to be about “hardware” — planes, ships and tanks — but there is now an increasing power and influence that comes from having the best “software”: essentially, information-handling platforms. “Hardware is still important, but these days your ability to compete and win is coming from the software and the data that you can get onto those platforms,” he said.

Andy Mitchell, a Deputy Director in Navy Command, agreed. “Electronic warfare — the digital, ‘cyber’ element — is much more prevalent now,” he said. “We have to look at how that changes how we’re going to fight, procure and operate.”

AI systems and simulation are likely to play

The panel of experts (clockwise from top left):

Lieutenant General Tom Copinger-Symes
Deputy Commander of
UK Strategic Command

Andy Mitchell
A deputy director in Navy Command

Patricia Lewis
Director of the International Security
Programme at Chatham House

Julian Cracknell
Chief Technology & Information Officer
at BAE Systems

a much more important role because they allow decision-makers to wargame many different scenarios. Simulations also have a relatively low carbon footprint, said Julian Cracknell, Chief Technology & Information Officer at BAE Systems. "They allow us to think about the "what if…" situations, to simulate them many times and identify options to de-escalate or prevent things," he said.

Difficult decisions about future conflict are not always about how to procure and use the latest kit. When it comes to autonomous systems, decisions have to be taken about limiting their use too. "We've got fully automated systems at the moment, but we use them only in very specific circumstances," said Mitchell.

That's because many ethical and legal issues about decisions to use or invoke AI systems are still in flux. "What we're really talking about is the issue of accountability," said Patricia Lewis, an arms control expert at Chatham House, an independent policy unit. It's not clear who is accountable for those decisions, she pointed out. "Is it the programmer? The procurer? The government? The military? Or the person who says 'go ahead and let the machine do it'?"

There are no easy answers, but we are set to learn more as we implement military AI away from the action. "I like to look at the wider range of autonomous and robotic systems," said Copinger-Symes. He cites logistics as an example: AI is dramatically speeding up the work of fulfilment centres, and we might learn a lot about optimising human responsibility from examining what goes on in those circumstances.

In the end, the best course of action will always involve hiring talented people who share and mould an organisation's values. "The young people we are trying to get into defence, particularly in digital and cyber areas, care deeply about the values of the organisation that they work in," said Copinger-Symes.

The next generation's values tend to include facing up to, and minimising, the effects of climate change. "They are expecting us to look after the planet; this is not debatable for them," said Copinger-Symes.

That's something that defence establishments in many parts of the world are trying to tackle — with mixed success.

"There is a very difficult challenge ahead for ministries of defence around the world to reduce their own carbon footprint," Cracknell said. There are decisions to be made, for instance, about vehicle types and fuel types. "Most will come with some compromise from an operational point of view — do we pick a fuel that has a lower carbon emission but is less effective fuel from a combat perspective?"

Lewis points out that climate change will also affect the operations themselves. With more extreme weather events, melting Arctic ice opening up strategically important waters, the potential for food wars and mass migration, military decision-makers are facing a new set of challenges. "We need to think this through in terms of conflict prevention," she said.

But the UK's experts are reasonably optimistic that the right systems can be put in place to make the future better than the present. For Mitchell, that optimism comes from his confidence in colleagues, whether they are in defence, academia, industry or government and policy. "We're at an inflection point, pivoting from hardware to digital, and changing the way we operate, but we've got the right people in place to deal with this," he said.

More at: www.baesystems.com/careers

OUT OF THIS WORLD

The UK has a mature space industry with ambitions to become a leader in small satellite launches. Communications, navigation and earth observation satellites play an ever more important role in planning and executing military manoeuvres, and in facilitating civilian activities such as commerce, finance and navigation. However, they are potentially vulnerable to attack and not easily replaced.

"Many of our policymakers don't understand how important space is for all of our industries," said Chatham House's Patricia Lewis. "We do need to think about what would happen if these space-based assets don't function properly."

Julian Cracknell of BAE Systems was confident that the vulnerabilities can be addressed. "We're seeing the democratisation of space: reduced launch costs and more processing power on ever-smaller satellites," he said. For military purposes, that means we can have a large number of relatively cheap satellites that can do the job of the small number of very expensive satellites in the current generation.

"That gives you an element of redundancy and the ability to respond to damage by getting more up into orbit quickly," he says. So although damaged satellites could be problematic in the short term, systems like the GPS satellites could be replaceable Cracknell reckoned "in relatively short order".

Hunting human origin stories

From a bone fragment of a mysterious new species to the latest on cave art, a powerful book shows how science is rewriting the past, finds **Alison George**

Book
Homo Sapiens Rediscovered
Paul Pettitt
Thames & Hudson

Upper Palaeolithic art on a replica of the Chauvet cave, south-east France

ANDIA/ALAMY

WHO are we? This fundamental question has always exercised humanity. One way to approach it is to look at our origins and the evolutionary journey we have taken. Today, thanks to powerful new tools, we can look at the lives of our ancestors in unprecedented detail: the meals they ate, their relationships. And through their art and other practices, we can even get hints about their beliefs about the world.

Paul Pettitt, an archaeologist at Durham University in the UK, is keen to share the "many untold stories" with us in his book, *Homo Sapiens Rediscovered: The scientific revolution rewriting our origins*.

We are in good hands. As a specialist in prehistoric art, dating techniques and how ancient peoples dealt with the dead ("mortuary activities" as they call it in the field), Pettitt has been at the forefront of major finds. He was part of the team behind the 2003 discovery of Britain's only known Palaeolithic cave art – engravings of a deer and abstract signs carved more than 13,000 years ago at Creswell Crags, a limestone gorge in England. Then there was the 2018 research he co-authored with its big reveal: Neanderthals made the world's oldest cave art.

His book lives up to its subtitle, with the "scientific revolution rewriting our origins" as a major theme. Using DNA sequencing, we can now make big discoveries from the tiniest scrap of bone. For example, DNA from the smallest finger bone, found in a Siberian cave, revealed the existence of the Denisovans, a mysterious sister group to the Neanderthals. Just as exciting is other genetic analysis showing that *H. sapiens* bred with both of these other humans.

Other tools are also proving their worth. Analyses of isotopes in the stalactites that can form over cave paintings have shown that many are far older than we thought. And the isotopes in teeth and bones can reveal surprising details about an individual's diet, such as how river fish were a crucial part of the diet of *H. sapiens* in Europe between 30,000 and 20,000 years ago, perhaps as a fallback for the times when the game they mainly relied on wasn't available. In fact, Pettitt argues that this ability to adapt in tough times might have been a key factor for survival during the bleakest days of the last glacial period.

Paul Pettitt helped establish Neanderthals as the first cave artists

But it is beliefs and behaviours that most interest Pettitt – getting a glimpse of the inner lives of long-dead people through the drawings they made on cave walls and the way they treated their dead.

The book takes us on a vivid journey through this prehistoric world, starting with the earliest origins of the *Homo* genus and its forebears in Africa, and the subsequent migrations of humans around the world. But Pettitt's major stopping-off point is Europe from around 40,000 years ago, where we visit paintings in the back of dark caves and campsites built out of mammoth bones.

Pettitt's personal experiences make for good stories. He writes that working in the Altamira cave in northern Spain, with its stunning images of bison that appear to drip out of the ceiling, was "the closest thing to a religious experience I've had". He also describes the sadness he felt looking at the red-stained bones of two infants in Austria, who had died around 30,000 years ago and were buried curled up together as if they had fallen asleep.

It is the little details he gives that bring this world alive, such as a "remarkably soft and warm" shawl made from nettle fibre, a recreation of a fabric that was probably made by people living in what are now Slovakia and the Czech Republic around 30,000 years ago. In fact, we have prehistoric humans to thank for many things: sewing needles and tailored clothing, jewellery, burial of the dead, art, dogs, weapons, tents, lamps and villages.

One disappointment was that a key finding in the field is barely discussed: the discovery of cave art in Indonesia that is comparable with – and as old as – that found in Europe, suggesting it was widespread among humans before this time.

Despite this, *Homo Sapiens Rediscovered* is a good place to start if you want a vivid view of where we have come from and what makes us who we are. ▮

Tragedy on Whakaari

The heartbreaking story of tourists trapped on a volcanic island during a major eruption is subtly told, says **Gregory Wakeman**

Film

The Volcano: Rescue from Whakaari

Rory Kennedy

Selected cinemas from 9 December and Netflix from 16 December

AT THE start of *The Volcano: Rescue from Whakaari*, the documentary warns viewers that it contains "material related to a real-life traumatic event" and "viewer discretion is advised".

This is a wise move. Director Rory Kennedy never actually shows gruesome footage of the raw injuries received by those on the volcanic island of Whakaari when it erupted on 9 December 2019. But the intimacy with which she directs justifies the caution, as she recreates the tragedy using interviews and survivor footage.

Situated in New Zealand's north-eastern Bay of Plenty region, Whakaari – also called White Island – was a very popular tourist destination, and 47 people were on the island when it erupted at 2.11pm local time. Twenty-two died. The rest experienced severe burns and injuries that required intensive care as a result of the rock, ash and steam spewing onto them.

Kennedy has directed many documentaries, including *Ethel*, about her mother's life as a member of the Kennedy family (she was married to Robert F. Kennedy).

Here, she takes her time establishing why so many visitors were on Whakaari that day. We see striking shots of what made the volcano such an attraction.

> "We hear their stories as they relive total darkness, unbearable heat and hearing people prepare to die"

Her footage shows steam emerging from soil, bubbling water in puddles, an acid lake, craters, and bright yellow and white sulphur chimneys.

But you can feel Kennedy ratchet up the tension, assisted by the talent aboard the documentary's creative team. Executive producers include A-lister Leonardo DiCaprio and Academy Award winners Ron Howard and Brian Glazer, while Hans Zimmer – who is now involved in David Attenborough documentaries – and Steve Mazzaro wrote the doom-laden score.

Thanks to the brave interviews of the survivors – including Matt and Lauren Urey, Jesse Langford, Geoff Hopkins, Brian Depauw and Kelsey Waghorn – Kennedy builds a moment-by-moment account of the day. In the end, it is the survivors' stories, and the videos and audio they recorded during their escape, that make the documentary compelling.

In particular, the Ureys' accounts increase the suspense. They give a strong sense of the volcano's natural power. Lauren says she felt something was amiss when she heard the volcano had erupted in 2013 and 2016, and was nervous even before she got to the island.

We hear the Ureys' heartbreaking stories as they relive total darkness, unbearable heat and hearing people preparing to die. Watching from within such an intimate viewpoint as chaos unfolds makes *The Volcano* all the more painful.

The camera footage is mostly too shaky to make an impact, although there are some spectacular close-up shots of the plumes of smoke taken from a boat that had just left the island. But the audio of people running for their lives, the rumbling sound of the eruption and the sheer panic are truly evocative.

Despite hearing about the survivors' excruciating pain and seeing the lasting effects of injuries they experienced, *The Volcano* is ultimately hopeful. Those who survived are still seeking answers. But they were saved thanks to the courage and kindness of strangers – a boat that had just left the island returned and picked them up. This is a message Kennedy delivers deftly, making the documentary even more inspiring and powerful. ▮

Gregory Wakeman is a writer based in Los Angeles, California.

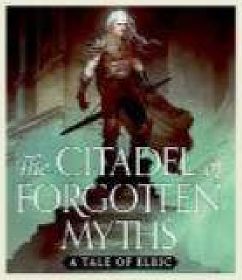
Steam escaping from inside the deadly volcano on Whakaari was once a tourist attraction

NETFLIX

Don't miss

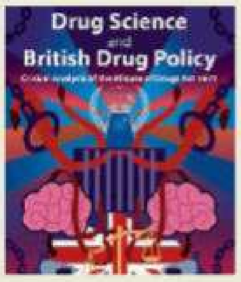
Watch

Avatar: The Way of Water is the first of four sequels to director James Cameron's 2009 sci-fi hit. Ronal (pictured) is joint leader of the Metkayina clan and is at the heart of the movie. Showing in cinemas from 16 December.



Read

The Citadel of Forgotten Myths by Michael Moorcock sits between the first and second books of the *Elric Saga*, his epic fantasy series. It is the story of an emperor battling his conscience and the thirst of his evil sword. On sale from 8 December.



Visit

50 Years of Failed Drug Policy in the UK are discussed by David Nutt's expert panel at the launch of the Drug Science podcast's new book (above). London's International Students House on 12 December at 6.30pm GMT.

DISNEY

A twitcher's paradise

A new book on the rise of birds isn't easy going, but it shows why they were vital to evolutionary theory – and birders will love it, says **Simon Ings**

Book

How Birds Evolve

Douglas Futuyma

Princeton University Press

THE delight is in the detail of a new evolutionary history of birds, as is some of the devilry – for this isn't a light read. Douglas Futuyma is out to tell a double tale: he explains how the study of these animals advanced our understanding of evolution and he shows how advances in evolutionary science solve some long-standing ornithological mysteries, even as they expose others.

Futuyma has written *How Birds Evolve: What science reveals about their origin, lives, and diversity* for birders, and being a birder himself (he began bird-spotting around the age of 11 in New York's public parks), he knows how fiercely the bug can bite. Many birders are halfway to being field scientists already, and a lot of celebrated practitioners of field work, such as Ernst Mayr, Konrad Lorenz and Niko Tinbergen, have been birders.

"I suspect few of my teachers in the 1960s imagined that we would be studying birds by combining information from geology and molecular biology – disciplines that are miles apart," writes Futuyma, giving readers an early hint of the complexities to come.

Birds, he reminds us, are both a curious and curiously productive field of study for evolutionary biologists. They are less useful in understanding the mechanisms of evolution than insects, plants and bacteria because they don't reproduce as quickly, but, being various and everywhere, they are vital to the study of behaviour, longevity, ecology, speciation, cultural evolution and a host of other things.

THOMAS B. SMITH; DANIEL LOPEZ-VELASCO

A Wilson's bird-of-paradise (top) and two seedcrackers (below)

The ability to study bird populations and how they interact gave evolutionary biologists a foretaste of what their science would become. "The models of how variation might persist," Futuyma writes, "were developed by evolutionary biologists who might not have known a hawk from a handsaw, but were adept in mathematics."

Applying lessons from birds to ourselves, though risky, has also proved irresistible, and, at least in evolutionary science's early days, very useful. In pondering human evolution, Charles Darwin developed the idea of sexual selection, which takes up more than half of his *The Descent of Man* of 1871. "Darwin devotes four full chapters to birds and cites at least 170 species," Futuyma points out. "Birds provided more evidence for his ideas about sexual selection than any other group of animals."

To grapple with bird diversity, one pretty much has to conjure up an idea of evolution. Peculiar and apparently useless features abound in the avian world, a sure sign of unceasing adaptation. To complicate matters, there are also many instances of convergent evolution. Feathers may have evolved only once, and through a bizarre genetic accident at that.

"Peculiar and apparently useless features abound in the avian world, a sure sign of unceasing adaptation"

Feather and wing shapes, however, recur again and again in even distantly related species. As Futuyma reminds us, Darwin once predicted that our classifications "will come to be, as far as they can be so made, genealogies", but even his credulity would have been stretched by news that flamingoes are very closely related to grebes.

Futuyma unpacks the story of evolutionary science alongside the story of how birds evolved, acquiring bipedal locomotion and simple filamentous feathers as Dinosauria, then clavicles fused into a wishbone in Theropoda, on and on, until we arrive at what we might as well call the modern bird, with its large, keeled breastbone, rapid growth and unfeasibly lightweight construction.

How Birds Evolve isn't meant as an introduction to birds, much as readers of *New Scientist* might lap one up, but it is entertaining and passionate. Futuyma, an evolutionary biologist who is the author of textbooks on the subject, is out to inspire, and his new offering more than makes up in sheer wonder what it might lack in an easy and seductive narrative. ■

Simon Ings is *New Scientist*'s film columnist

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JASON FORD

Who do you think you are?

When it comes to knowing thyself, your own opinion doesn't necessarily align with that of people around you. But who is right? And would it make life better to fathom your true nature, asks **Daniel Cossins**

EVER wondered what other people think of you – I mean, what they really think of you? I consider myself decent company, for instance, even if I know I get a bit vociferous after a few pints of bitter. I like to think I am open-minded and considerate, too, though I recognise I can be dismissive at times. But lately, particularly the morning after a few of those pints, I have become curious about how other people see me.

Let's be honest: sometimes I wonder if people think I'm more obnoxious than I realise. Because presumably you wouldn't know. That is partly where the intrigue lies for me. How accurately do we see ourselves? And who is the real you anyway – the person you think you are, or the person other people see?

It isn't that I am self-obsessed, you understand. I am just intrigued about the extent to which the way people see my personality tallies with the way I view myself. Ultimately, I wonder whether being more aware of these shadowy hinterlands of self-knowledge might make life better – not only for me, but for those who spend time with me. Did I say I wasn't self-obsessed?

In search of answers, I did what most sensible people tend to avoid: I solicited honest insights into my nature from a dozen friends, family members and colleagues. I asked them to fill out a 60-point questionnaire designed by psychologists to assess personality, and to give the two traits they most associate with me – one positive and one negative. Then I waited nervously for the scales to fall from my eyes.

The call to "know thyself" echoes from antiquity. Socrates famously declared that the unexamined life isn't worth living. But for the ancient Greek philosophers, the pursuit of self-knowledge was a dialogue with others to figure out human nature and how to govern. The focus on introspection came to the fore later, in the 17th century, with René Descartes. "The idea that we sit and just reflect on ourselves, that navel-gazing, is distinctively modern and Western," says Mitchell Green, a philosopher at the University of Connecticut who has studied self-knowledge.

In one sense, it is impossible to avoid knowing yourself. You are constantly thinking about how you feel, what you are going to eat tonight and so on. In addition, we each have privileged knowledge of our own personal history, our own thoughts and feelings and what we get up to when no one else is looking. So you might think we know all there is to know about our true selves, which I am defining here not as some immutable inner essence, but as the way you typically think, feel and behave over years or decades. Your personality, in other words. And yet it is far from clear that we can gain an accurate picture even of that.

For psychologists, the question is an empirical one. The trouble is that self-perception presents a particularly thorny case of the "criterion problem" – that is, how can you assess the accuracy of the way you perceive yourself without an objective criterion for comparison? In recent years, researchers have tried to overcome this by comparing self-perceptions with other people's perceptions of you. "There is no direct pipeline to your true self," says Simine Vazire, a psychologist at the University of Melbourne in Australia. "How a group of other people, who know you well across different contexts and who have different biases to one another, see you might be the closest you can get to a good accuracy criterion for what you're really like."

In a few studies, researchers have been able to compare self-perceptions with third-

> **"There is no direct pipeline to your true self"**

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TOLGA AKMEN/AFP VIA GETTY IMAGES

Friends may be less biased in their opinion of you than your family members

party observations of behaviour. One group compared people's self-ratings on their core personality traits with behavioural indicators of each of those traits in a lab environment, and found that there was a reasonably good correlation between self-perceptions and actual behaviour. Similar results have been reported from experiments in real world settings, where researchers measured behaviour using audio recordings of participants' daily life.

"Our self-perceptions do generally predict our behaviour pretty well," says Lauren Human, a psychologist at McGill University in Montreal, Canada. They also correspond well with the perceptions of people who are close to us, she says. That chimed with my own feedback experience. I used an online version of a test called the Big Five Inventory-2, which is based on a model that psychologists use to assess personality. It divides our personalities into five independent traits: extroversion, agreeableness, conscientiousness, openness to experience and neuroticism and gives you a score out of 100 for each. When I took the test, I scored highly on extroversion (71) and open-mindedness (96), middling on agreeableness (65) and low on neuroticism (48) and conscientiousness (46).

When other people's perceptions of me came trickling in, I was struck by how similar they looked to my own. There were a few differences, of course. On the test, several people rated me higher than I did on extroversion and conscientiousness, for example. A handful of my volunteers very much warmed to their second task, sending a barrage of negative traits they associate with me that aren't captured in the Big Five scores. Highlights included "strident", "belligerent", "intractable" and – from someone we will call Ben because that is his name – the instant classic, "Is there a German word for not letting you get a word in edgeways?"

But it's not as if I wasn't aware of those traits, even though I can now see that I might have underestimated their extent. So, broadly speaking, the discrepancies between self and others' perceptions were small enough to make me think I know myself pretty well.

Illusory superiority

As you might expect, however, the devil is in the detail. Psychologists have demonstrated again and again that the way we see ourselves is modulated by a smorgasbord of cognitive biases that serve to make us all, to a greater or lesser extent, deluded about who we are. "Our self-perceptions are far from perfectly accurate," says Vazire.

We tend to be most deluded when it comes to personality traits we consider highly desirable or undesirable. "We overestimate ourselves on the traits that are important to us, and traits that are ambiguous too," says David Dunning at Cornell University in New York. That can manifest as "illusory superiority", where people overestimate their qualities and rate themselves more favourably than others do. For example, Vazire found that students' self-reports of intelligence were generally inflated compared with results from IQ tests and other people's perceptions. Whether we are deluding ourselves about our smarts, our physical attractiveness or our charisma, we seem to do it to enhance our sense of self-worth and social status. I fear I may have fallen into this trap when rating myself as 96 in "open-mindedness", while several others rated me in the low 70s. One so-called mate even

SOLSTOCK/GETTY IMAGES

How to see yourself more clearly

ASK YOUR COLLEAGUES

Your cognitive biases and blind spots mean that other people see your true personality more accurately than you do, especially when it comes to traits you value (see main story). One way to tap into that is simply to ask them – if you think you can handle honest feedback. You can find so-called self-peer personality tests online.

But you should beware that everyone has their own biases and those closest to you are probably the most biased about you. This is why close family might not be the best judges, says Simine Vazire at the University of Melbourne, Australia. "The ideal person is someone who knows you well but whose identity is not fused with yours – a long-term colleague who you've also spent time with outside of work, for example."

EXAMINE YOUR BIASES

If one measure of our true personality is how we unconsciously think about and behave towards others, rather than how we consciously believe we do, then one way to get to know the real you is to take an implicit association test – a quick-fire method of exposing your hidden biases. "This is something you can't know through introspection," says Mitchell Green, a philosopher at the University of Connecticut.

There is some debate about the reliability of such tests, but given the multiple problems associated with trying to figure all this out by yourself, they are probably more reliable than your own self-judgement. And it is surely useful to be aware of how society has shaped your assumptions about others.

PRACTISE MINDFULNESS

A key barrier to self-knowledge is what is known as motivated reasoning: if we put a premium on being charismatic or intelligent, say, we overestimate such qualities in ourselves because it wards off negative feelings and makes us feel good.

In which case, Erika Carlson at the University of Toronto in Canada has argued, mindfulness – paying attention to your thoughts and feelings in a non-judgemental way – may be a good way to overcome such barriers. The idea is that it can reduce emotional reactivity and thereby mitigate the drive to delude ourselves. Carlson has suggested that greater bodily awareness might also make us more aware of our non-verbal behaviour, such as frowning or grimacing.

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rated me as low as 43 on "agreeableness".

On the flip side, many of us seem to underestimate our qualities and doubt our abilities compared with those of others – a phenomenon known as imposter syndrome. "Whether you tend toward one or the other depends largely on your self-esteem," says Vazire. The students in the study mentioned previously with low self-esteem underestimated their intelligence, while the confident ones thought they were smarter than they really were.

In many cases, then, other people see us more clearly than we see ourselves. Or at least you can argue as much so long as you accept that the consensual perspective of third-party observers offers a more objective view of you than your own, even if each of them inevitably has their own biases and blind spots. Human says "other people's perceptions often predict people's behaviour better than self-reports".

There are nuances here, too. When Vazire compared ratings of personality with behaviour in video recordings of lab-based tasks, she found that friends' ratings were more accurate than self-ratings for traits such as intelligence and creativity – but that the opposite was true for neuroticism. So maybe it is more accurate to say that those who know us well see things we don't see in ourselves, particularly when it comes to aspects of our personality that we care about and thus find it harder to judge accurately.

> **"To a large extent, you are what most others think of you"**

Generally, insofar as there is anything approaching objective truth about who you are, it lies in an aggregate of other people's perceptions. In which case, I am not the person I think I am after all. "To a large extent, you are what most others think of you," says Daniel Leising at the Technical University of Dresden in Germany.

The problem for me is that my perceptions of how other people see me, known as metaperceptions, are broadly aligned with how they actually see me according to how they scored me on the Big Five personality traits – notwithstanding my underestimation of how deeply annoying I can be in full flow. The thought occurs to me that maybe all this would have been juicier had it turned out people really do think I'm obnoxious. But when I reflect on the overwhelming agreement among them that I am belligerent and loquacious, I can see what Leising means when he says that our metaperceptions are often wide of the mark.

The upshot is that if you want a complete picture of your personality, you ought to seek out some feedback. For Green, author of a book called *Know Thyself: The value and limits of self-knowledge*, the idea of the "adaptive unconscious" adds support to the argument. This is a set of mental processes that affects ›

DAISUKE TAKAKURA

Knowing who you really are allows smoother interactions with others

judgements and decision-making but lie out of reach of the conscious mind. "If the adaptive unconsciousness is plausible, and there is lots of evidence to suggest it is, then you're not likely to know about your blind spots and implicit biases through introspection," says Green.

It's not that introspection isn't important. It's more that "you need the relatively objective, third-party perspective too", he says. "I would add that you have to beware, though, because hearing honest, in-the-round scrutiny of your personality can be a bit uncomfortable. There's a reason that direct, honest feedback is rare."

In my case, the Big Five personality scores weren't even remotely upsetting. But when it came to the choice words a few people proffered for my most overwhelming negatives, well, I can imagine that sort of feedback isn't for everyone.

Better life decisions

Which brings us to the other big question: is the pursuit of self-knowledge even worth it? What do we actually gain by peering into our blind spots to get a more accurate, more complete understanding of who we are (see "How to see yourself more clearly", page 39)?

Having more accurate self-views is generally considered to be a good thing, says Human. "This is because knowing our personalities should help us make better life decisions" – what careers to pursue, who to form relationships with, and so on. "It also enables us to have smoother interactions with others and provides a subjective sense of coherence and meaning." A study she published with colleagues in 2020, for instance, showed that people who agree more with others about their personalities report greater well-being.

> **"If we don't know ourselves, we are in danger of pursuing things we don't want"**

That makes sense. The problem is that most of the evidence that supports such conclusions is correlational. "It's difficult to know whether self-knowledge promotes well-being or well-being promotes self-knowledge," says Human.

Vazire tends towards the sceptical. "The goal of my research was not just to look at how well people know themselves, but also why it matters: whether people with greater self-knowledge have better life outcomes," she says. "But the truth is that we don't even know if self-knowledge is good for you or not. The evidence is totally inconclusive. It's an open question." It is possible to imagine a study that compares people with good self-knowledge with a control group and tracks them over decades to see if they have better long-term outcomes in their health and relationships. But no such studies exist, and possibly for good reason. "The idea that we could intervene on self-knowledge to improve people's lives depends on the idea that self-knowledge is measurable, that it's good for you and that we can change it. The truth is we barely know the first thing," says Vazire. Human says something similar: "It hasn't been empirically demonstrated yet that people can make these changes and that these can, in turn, enhance well-being and positive social outcomes."

As Vazire points out, it is possible that when it comes to well-being, or happiness, biased beliefs offer better outcomes. Indeed, it has been proposed that there is an "optimal margin illusion" that hits the sweet spot between seeing yourself positively but not distorting reality so much that it causes problems in your relationships and career. That said, she does suggest that accurate self-perceptions might make the people around you happier.

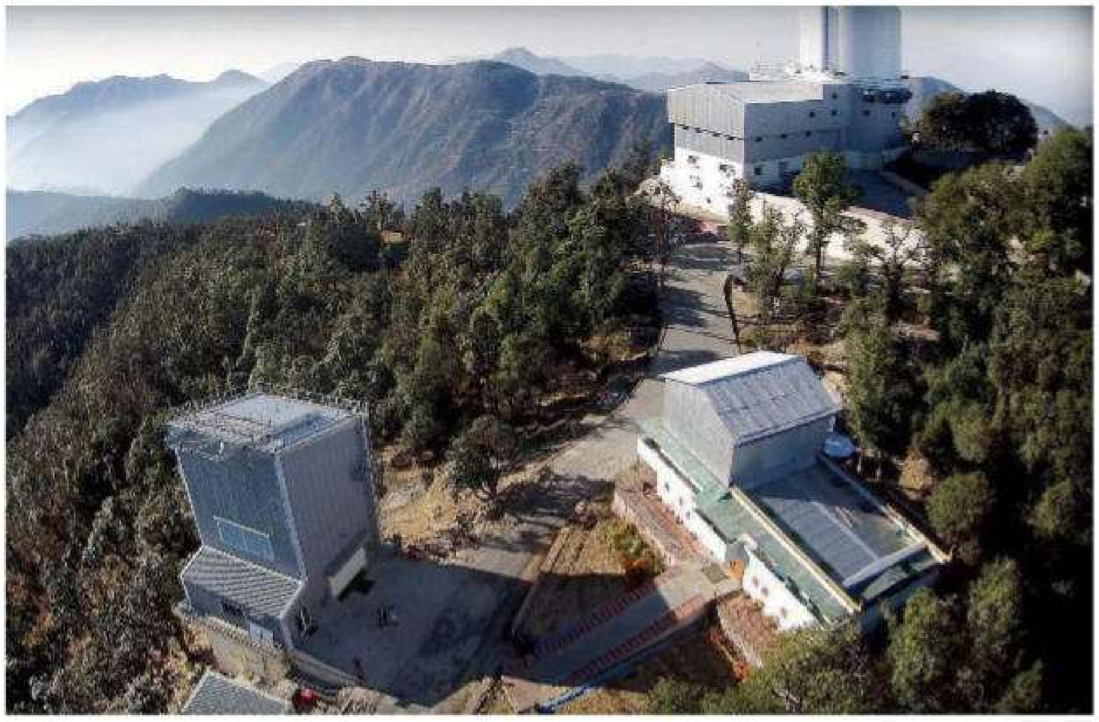
Green's instinct lands somewhere in the middle. "I do think self-knowledge, in this more expansive sense that includes other people's perceptions, is valuable, though I don't claim to be able to cite rigorous studies to back that up." Rather it is an intuition largely based on the notion that our self-perceptions greatly influence our relationships and the life-defining decisions we make. "If we don't know ourselves, we are in danger of wasting our efforts in pursuit of things that we don't genuinely want or care about," says Green. In that sense, perhaps it is more beneficial to figure out what is truly important to you.

For my part, I would have to admit that tapping into other people's perceptions of my true nature held no epiphanies. The scales haven't fallen from my eyes. I do think it was a worthwhile exercise, however, because I now have a much clearer idea of where my delusions lurk – and I will most definitely be working harder to stop talking over people. "Obviously, your reputation is a signal of the impact you are having in the world," says Vazire. "And what you're subjecting other people to." ▮

Daniel Cossins is head of features at *New Scientist*

THE LIQUID TELESCOPE

A unique telescope with a liquid mirror has finally opened its eye on the universe. This innovative design could pave the way for an observatory on the moon, says **Sushmita Pathak**



JEAN SURDEJ

A 4-metre liquid mirror telescope with a retractable roof (left) sits next to two optical telescopes in the Indian Himalayas

ATOP an Indian mountain sits a 4-metre-wide reflecting basin, its ripple-free surface mirroring everything above it. It is as if someone scooped up a piece of the Bolivian salt flats, the world's largest natural mirror, and put it in the Himalayas. But unlike South America's Salar de Uyuni, where the salt plains covered by water produce incredible reflections that draw many sightseers, the basin on the mountain is filled with liquid mercury. And this is no tourist hotspot: it can only be accessed by a small group of scientists who use it to observe the heavens.

The basin is part of a unique telescope. Situated in an observatory in the northern Indian state of Uttarakhand, the International Liquid Mirror Telescope (ILMT) uses the pool of shiny metal to gather light from the skies.

Such telescopes have benefits over conventional ones. Most importantly, they are much cheaper to build. But although the idea of a liquid telescope has been around for centuries, creating a viable one has proven fiendishly tricky. The ILMT was in the works for more than a decade. This year, it opened its eye for the first time. It is the largest of its kind, and the first built to carry out astronomical observations.

The telescope scans the night sky in the hope of spotting new phenomena – when it isn't raining, that is. But astronomers hope the potential of these devices will one day reach far higher than Earth's mountain peaks. One day, they might even allow us to build a mega telescope on the moon to get a glimpse of the first stars in the universe.

The basic concept of a liquid telescope is surprisingly simple. Just like your morning coffee, if you stir a liquid, its surface will form a dish-like shape that, it turns out, is perfect for focusing light. "The idea was, if we can find a reflective liquid and rotate it with a very precise control system, it would focus light from above onto a detector and we could

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> “A liquid mirror telescope can only look straight up. That can be a bonus”

use that as a telescope,” says Paul Hickson at the University of British Columbia in Canada, one of the main scientists on the ILMT.

This concept can be traced back to the 17th century and Isaac Newton. But it wasn’t until the late 19th century that anyone tried to build one. The most notable attempt was by US physicist Robert Wood who, in the early 1900s, constructed a small prototype 5 centimetres in diameter. But Wood’s creation was far from perfect: the mechanism he used to rotate the mirror created ripples in the mercury and he had trouble making the dish that held the metal spin at a constant speed. In 1922, a “monster telescope” 15 metres in diameter was suggested. The aim was to observe Mars and any inhabitants – the subject of fevered speculation in the early 20th century – as the planet came close to Earth in 1924. But the telescope never materialised.

For several decades, working liquid telescopes remained a figment of people’s imaginations. Then, in 1982, Ermanno Borra at Laval University in Quebec, Canada, found a solution to the technical challenges, such as the ripples that had plagued Wood’s creation and other early attempts. He suggested dampening vibrations by pumping a thin layer of air between the basin that holds the mercury and the motor that rotates it. Borra also suggested pouring a liquid resin on the dish surface first, letting it dry into the right shape, then pouring reflective liquid onto it as a coating, cutting down the amount of mercury needed.

These tweaks led to a flurry of projects. In 1994, Borra and his colleagues, including Hickson, built an experimental 2.7-metre-wide liquid mirror telescope near Vancouver, Canada. Hickson also worked with NASA on a 3-metre liquid telescope in New Mexico to observe space debris and, in the early 2000s, the University of British Columbia built the experimental 6-metre Large Zenith Telescope on a hilltop just outside Vancouver. “We used it mostly for engineering, to solve problems that arise when you go to larger and larger diameters,” says Hickson. It was also used to study the sodium layer in Earth’s atmosphere, but it wasn’t suitable for space observations, because of the cloudy weather near Vancouver. It was decommissioned in 2016.

Still, the Vancouver project confirmed what many astronomers had suspected, that these telescopes are much cheaper to build than those with solid mirrors. Conventional instruments use glass mirrors to reflect light coming from stars and other cosmic objects. The mirror surface can’t have even the slightest of bumps, which means polishing it to be precisely smooth to a fraction of the wavelength of light.

Achieving such accuracy becomes almost impossible in large telescopes. One workaround is making several smaller mirrors and then aligning them to form a big surface. But even then, it is a costly and complicated affair. The mirrors, which form a big chunk of the cost, can make a large telescope economically unviable. Liquid mirrors, on the other hand, cost a fraction of glass ones – 1 per cent of the cost, according to some estimates – making them ideal for large telescopes. The 4-metre ILMT cost around $2 million, whereas the 3.6-metre optical telescope it sits next to came with a price tag of $17 million.

MICHAEL DESJARDINS

In a liquid mirror telescope, light reflects off a pool of mercury

ARIES

Still, cost savings are irrelevant if we can’t build a working liquid mirror telescope. The ILMT was conceived in 1996 and was expected to be ready for use in 2009. But the project faced several delays. Getting enough mercury to fill the dish, 50 litres of it, was one challenge. Then, the construction of its protective dome was delayed until late 2016. The following year, two cranes and a truck made a slow climb up the mountain to install the 4-metre dish and other elements. Then came the coronavirus pandemic, setting back the ILMT by another year or so. “Strong determination kept the project alive,” says Jean Surdej, an astronomer at the University of Liège in Belgium who spearheaded the ILMT effort. In his eyes, it was worthwhile because of its cost-effectiveness and the opportunity for studying the skies in a unique way.

Unlike regular telescopes, which can point to different places, a liquid mirror telescope

A 6-metre liquid mirror telescope in Vancouver was used to study Earth's atmosphere

can only look straight up at the patch of sky overhead, which astronomers call the zenith. This was initially considered a grave shortcoming because there was no way to target specific objects. These days, however, only observing one spot can be a bonus. "By looking at the same region of sky over and over again, you get this sort of time-lapse picture," says Hickson. It is a good way of detecting objects that appear fleetingly, such as supernovae and passing asteroids.

Usefully, the image quality for a telescope is best at the zenith, too. "The zenith is where the [incoming] light rays cross the smallest amount of atmospheric layer of the Earth, which means that transparency is the best there," says Surdej. Another advantage of the ILMT is its location, right next to India's biggest optical telescope. If astronomers spot something interesting through the ILMT, they can follow up with the other instrument.

Even though they are much cheaper to build than their glass counterparts, liquid mirrors come with their own tricky requirements. In the ILMT, the mirror dish floats on an air layer about 10 micrometres thick, much thinner than a human hair. The layer of mercury in the ILMT is about 3 millimetres thick and the mirror rotates once every 8 seconds. To prepare the surface of the dish that holds the mercury so it assumes the required paraboloid shape, scientists had to mix several buckets of chemical resin, climb on a beam directly above a spinning disc and pour the liquid onto the spinning surface before it hardened so it could take the desired shape. Getting the resulting 4-metre-wide dish up to the observatory, which is at an elevation of 2450 metres, was also quite an expedition. It even required breaking down a wall to widen the road at one spot.

Finally, in early 2022, Hickson and Surdej flew to India to assemble the telescope along with Indian scientists. They snapped on their protective masks, to stop them inhaling mercury vapour, poured the shiny liquid metal onto the surface and aligned the camera that captures its reflected light. "The first images were terrible, which is normal because the camera was not adjusted to the right position," says Hickson. After tweaking the settings, the team achieved its first viable observation in the second week of May. "We were all very happy when we got the first images," says Hickson. "We opened a bottle of wine."

The telescope is only operational for about eight to nine months a year, taking a break between July and October during the main part of India's monsoon season. The mercury is removed and the sliding roof that opens when the telescope is observing is covered. The team will carry out tests to align all the elements, before restarting observations in early January.

New visions

Observations so far include a rich stellar field in the Milky Way and NGC 4274, a galaxy in the Coma Berenices constellation. These are known objects. The hope is that the ILMT will find something entirely new. "Many discoveries that have been made in recent years have just been sort of unexpected," says Hickson. "You don't know what might turn up."

There is a lot riding on the ILMT. If it proves successful, it could lead to new liquid telescopes in other parts of the world. The University of British Columbia had plans for an 8-metre telescope on a peak in Chile, but the project is on hold because of a lack of funding.

Many hope the future of liquid mirror telescopes lies further afield. NASA is conducting experiments to see if fluids can be used to make other parts of a telescope in space. Without gravity, any blob of liquid eventually takes a perfect spherical shape, which can be used to make a giant lens. When tested in simulated microgravity environments, liquid lenses have proven as good as or better than glass lenses, and only take a fraction of the time to make.

The ultimate dream, for astrophysicist Anna Schauer at the University of Texas at Austin at least, is to build a giant liquid telescope on the lunar surface, to peer at the first stars in the universe. Schauer and her colleagues are studying the viability of a 100-metre-diameter version to look at an elusive group of objects called Population III stars – thought to be the first stars to have formed after the big bang and to be made entirely of hydrogen and helium. These are believed to exist in smaller clusters and are so faint that even the James Webb Space Telescope is unlikely to be able to see them. To do so, scientists would need a telescope with an incredibly large mirror. This would be practically impossible to manufacture and extremely expensive to put on the moon – unless it is made of liquid.

A lunar telescope won't be made of mercury, though, as the metal is too dense to work properly on the moon's surface. One alternative is an ionic liquid, a salt in liquid form. Whatever the material, the instrument would be nestled in a crater near one of the moon's poles, and it would send data to a satellite in lunar orbit. Such a huge project is likely to take decades to materialise. But the ILMT's opening, after years of preparation, makes Schauer hopeful. "Reviving this technology and putting it to work on Earth is amazing," she says. "It's a great step in the direction of finally creating a liquid mirror telescope on the moon." ∎

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Bite club

It took a lot of meat to feed even one species of giant, flesh-eating dinosaur, but in some places three types lived side-by-side. Why didn't they starve, asks **Riley Black**

OF ALL the "terrible lizards", there was none quite so strange and imposing as Spinosaurus. This croc-snouted carnivore could reach 14 metres in length and weigh more than 7 tonnes. Those vital statistics put it in the running for the largest terrestrial carnivore of all time. The dinosaur even got a starring role as the central villain in the 2001 movie *Jurassic Park III*, spurring endless internet debates over who would really win in a toothy clash between this bumpy backed reptile and Tyrannosaurus.

In reality, such a fight would never have happened: Spinosaurus lived in northern Africa about 100 million years ago, while Tyrannosaurus stalked North America between about 66 and 68 million years ago. But that isn't to say that confrontations between colossal carnivorous dinosaurs didn't occur. Difficult as it may be to imagine multiple multi-tonne predators co-existing in the same habitat, such territory sharing was common during the Jurassic and Cretaceous geological periods. The question facing palaeontologists is this: how could multiple giant carnivores carve up a single ecosystem between them?

We are now closing in on an answer. Palaeontologists have spent decades piecing together the daily lives of dinosaurs like Spinosaurus and Tyrannosaurus, charting everything from diet to how these famous beasts grew up. As researchers put flesh on the bones of these huge carnivores and envisage the roles they played in their ancient environment, one thing is becoming clear: we may have fundamentally misunderstood the way they lived and hunted.

For more than a century after the word "dinosaur" was coined in 1842, no one really questioned why gigantic carnivorous versions of these animals – known as megatheropods – grew to such frightening sizes: they did so simply because the world of the dinosaurs was bigger. It was clear even in the 19th century that some herbivorous dinosaurs got mindbogglingly massive. Such big prey seemed to necessitate enormous predators. Megatheropods evolved to hunt megaherbivores.

But living large is rarely so simple. In recent years, an ancient ecosystem that existed in northern Africa about 100 million years ago has been held up by some as the most striking example of how strange dinosaur habitats could be. For years, the ecosystem unearthed in Morocco – known as the Kem Kem – has been revealing itself through a steady flow of fossils. In a 2020 publication, Nizar Ibrahim at the University of Portsmouth, UK, and his colleagues attempted to make sense of the evidence found there to date. They concluded that the animal community was astonishing.

Among the dinosaur predators, there was the 14-metre-long Spinosaurus, the 12-metre-long Carcharodontosaurus and the 8-metre-long Deltadromeus – along with an as-yet-unnamed megatheropod categorised as an abelisaur that was at least 5 metres long.

Big dinosaur predators probably had large appetites, no doubt to fuel their warm-blooded bodies. In fact, if modern predators are a guide, every megatheropod in the Kem Kem probably munched through several tonnes of food each year, and so the search for prey must have occupied much of their time – probably creating a landscape of fear for prey species. "This was arguably the most dangerous place in the history of planet Earth," said Ibrahim when the research was published.

PAUL BLOW

Yet it also seems to have been one of the most puzzling places. That is because Ibrahim's team concluded the Kem Kem contained very few large plant-eating dinosaurs for the megatheropods to eat. How did the predators not starve? For Ibrahim's team, the answer is to be found in the many waterways that once criss-crossed the Kem Kem. The team proposed that it was fish, rather than large plant-eating dinosaurs, that fed the carnivores found there.

In the eyes of many researchers, Spinosaurus certainly does have the look of a fish-eater – although whether Carcharodontosaurus and Deltadromeus also caught fish has yet to be assessed. Also unclear is how this variety of gigantic predators might have found enough aquatic prey to eat, even allowing for the fact that some of the fish in the Kem Kem are known to have grown to 4 metres in length.

While Ibrahim and his colleagues continue to investigate these questions, others caution that we still can't be sure that this proposed fish-fuelled, predator-heavy ecosystem existed at all.

It is important to appreciate that the sequence of rocks in which a prehistoric ecosystem is found often spans a vast geographical area and represents millions of years of time. Without detailed records of exactly where in that rock sequence the fossils of a particular dinosaur were found, it is difficult to know for sure which species it co-existed with. These scientific notes are often lacking for the dinosaurs of the Kem Kem.

Naturally, as they are partially located in the Sahara desert, the Kem Kem rocks can be difficult for researchers to work in. Indeed, many of the fossils from the area are unearthed by members of the local community. Some specimens end up fuelling the bustling domestic (and legal) fossil trade – others end up on the illegal black market. In both cases, the precise geological information that palaeontologists require to understand the ecology of the Kem Kem is often lost.

This has led some palaeontologists to suspect that the abundance of carnivores in the Kem Kem has been overestimated. "Fossils from the Kem Kem do not reflect the actual full diversity of the area," says Katlin Schroeder at the University of New Mexico. She thinks that describing what has been found so far as a complete picture of the ancient ecosystem "is no more accurate a representation of ecological diversity than a census at a steak › house is an accurate representation of the dietary trends of an entire neighbourhood".

Dinosaur footprints fossilised in the rocks also throw doubt on visions of a place with a surfeit of carnivores. While not as striking as the skeleton of a megatheropod, fossil tracks can be more ecologically informative. This is particularly the case since footprints stay put, whereas bones and teeth can be carried by rivers or floods and end up being fossilised a long way from where the animal they belonged to lived. In other words, says Matteo Belvedere at the University of Florence, Italy, footprints "are linked to the ecosystem".

If this ancient environment was full of enormous carnivores stuffing themselves with fish, then that should be reflected in the fossil footprint record. But it isn't. Most of the tracks found in the Kem Kem seem to have been made by medium-sized theropods, while footprints left by megatheropods are rare.

"My personal opinion is that the Kem Kem bone record suffers some bias," says Belvedere. The bone fossils might actually record a variety of different environments and communities of dinosaurs that existed in different parts of the landscape, he says. The bottom line: the most dangerous place on Earth may not have overflowed with hungry carnivores after all.

If that is the case, however, the Kem Kem might have been unusual – because we know for sure that other Jurassic and Cretaceous ecosystems did, in fact, boast several megatheropods living alongside one another. Moreover, through the study of these other ancient ecosystems we are closer to understanding how different sharp-toothed species could coexist.

Take the fern-covered floodplains of western North America in the Late Jurassic, about 150 million years ago. This environment is now preserved in a set of rocks known as the Morrison Formation – and for simplicity's sake, the dinosaur locale of that time is given the same name. "There really is no place on Earth today that serves as a good ecological model for the Morrison Formation," says Joseph Peterson at the University of Wisconsin Oshkosh.

On a safari through this corner of the Jurassic world, you might encounter plant-eating animals to rival the size of modern-day megafauna – the 3-metre-long armour-covered Mymoorapelta, for instance, or the 7-metre-long Stegosaurus. But these were far from the largest beasts you would come across. This is because the Morrison Formation was also home to a wide variety of truly enormous sauropods. These long-necked, plant-eating dinosaurs included Apatosaurus, Camarasaurus, Diplodocus and Brachiosaurus. Many of these had the potential to reach 20 metres or more in length, and some may have weighed 35 tonnes or more – as much as a humpback whale.

Then there were the megatheropods. The three-horned Ceratosaurus grew to lengths of over 7 metres. Allosaurus, meanwhile, averaged about 8 metres, but with some exceptional specimens growing a couple of metres longer still. Finally, there was the 10-metre-long Torvosaurus, a predator with a long skull and blade-like teeth. Together, these reptiles were among the first truly giant carnivores Earth had seen – and there is far more confidence that they co-existed because researchers have meticulous geological notes with which to reconstruct the ancient communities of the Morrison Formation.

Of the meat-eating menagerie, it is Allosaurus that palaeontologists encounter most often. Within the Morrison Formation is Cleveland-Lloyd Dinosaur Quarry in central Utah, where Peterson conducts field research. The remains of at least 46 Allosaurus have been found there – with the total number probably reaching into the hundreds.

Even discounting the astonishing abundance of fossils in this quarry, the megatheropods of the Morrison Formation seem to have been common. An analysis of dinosaur ecosystems published earlier this year by James Farlow at Purdue University, Indiana, and his colleagues estimated there was one for every five megaherbivores. So many, in fact, that it seemed like there wouldn't be enough meat to go around unless the carnivores were almost entirely indiscriminate about what they ate. Yet subtle anatomical differences between the megatheropods point towards different prey preferences. The nature of those preferences is still up for debate, but researchers are beginning to address the broader question: how might each sharp-toothed hunter have found enough to eat here?

Last year, a pair of biologists suggested

JIM WEST/ALAMY

The Cleveland-Lloyd Dinosaur Quarry in Utah is rich in fossils

TOLO BALAGUER/ALAMY

A fossilised dinosaur footprint in the Atlas mountains of Morocco

a partial answer. They used a computer simulation of the ecosystem to explore the Morrison Formation, and calculated that the natural death rate of gigantic sauropods should have been high enough to create a near-constant supply of rotting meat across the landscape. They suggested that at least one megatheropod, perhaps Allosaurus, could have survived more or less exclusively as a scavenger – like a gigantic flightless vulture moving between free meals. This would have reduced competition.

> **“This was arguably the most dangerous place in the history of planet Earth”**

In addition, assuming that megatheropods only had eyes and stomachs for the largest animals in the landscape ignores something fundamentally important about dinosaur ecosystems. Every dinosaur – even a 25-metre-long Diplodocus – hatched out of an egg that, in most cases, was no larger than a grapefruit.

Although we can be reasonably confident that all the herbivorous dinosaur species were having large clutches of tiny offspring, palaeontologists rarely find them in the fossil record. There are a few potential explanations for this. Perhaps the small and delicate bones of hatchlings were far less likely to fossilise than the larger and sturdier bones of adults. Or perhaps palaeontologists digging for fossils are more likely to overlook such tiny remains.

There is another possibility: young dinosaurs might have been a target – maybe even a preferred meal – of some species of megatheropod. This makes sense, given that young animals would have been easier to catch and kill than the strong adults, which could seriously injure megatheropods with the thrashing of their limbs and tails. To a growing Allosaurus, a young Brachiosaurus would have been Jurassic popcorn.

Farlow’s team suggested some large carnivores of the Morrison Formation might even have ignored large plant-eaters and their young to some extent. Rather than hunting megaherbivores, the megatheropods might instead have focused on smaller species of dinosaur – mirroring the way that the multi-tonne orcas in today’s oceans will often hunt salmon and seals rather than large sharks and whales. And if even that wasn’t enough? Adult Allosaurus had no qualms about eating each other, fossils from a Colorado site document.

In fact, the appetites of these megatheropods might have been so voracious that smaller theropod species couldn’t compete. That has everything to do with how dinosaurs grow up and how Jurassic and Cretaceous ecosystems differed from anything we know today.

“Most modern carnivore [communities] contain small, medium and large carnivores,” says Schroeder. But that diversity is lacking from the ancient environments where megatheropods roamed, according to an analysis Schroeder and her colleagues published last year.

Of course, “large” is a relative term here – in the Serengeti in Tanzania, for example, the largest modern carnivore is the lion, with males measuring about 2 metres in length and weighing about 250 kilograms. But alongside the lions there are medium-sized leopards, cheetahs and spotted hyenas – all in the 60 to 90 kg range – and smaller African wild dogs that weigh no more than about 35 kg.

ROGER DE MARFA/ALAMY

A fossilised sauropod dinosaur egg; most were no larger than a grapefruit

Compare that with a megatheropod ecosystem. “Dinosaur communities are different than modern communities in that medium-sized carnivorous dinosaurs are suspiciously absent or rare,” says Schroeder. In the so-called Dinosaur Park Formation – an ecosystem preserved in 75-million-year-old rocks of that name in Canada – the largest predators were tyrannosaurs like Gorgosaurus that could weigh more than 2 tonnes. According to the fossil record, the next largest carnivores weighed just 200 kg, leaving a massive carnivore “gap”. In our modern world, this would be the equivalent of there being no carnivores on the Serengeti between the lion and the bat-eared fox – a 5 kg predator that feasts on termites.

The biology of the megatheropods probably explains this gap, says Schroeder. Just like the herbivorous dinosaurs, megatheropods entered the world as tiny hatchlings. Adults laid such large clutches that young megatheropods must have made up a substantial portion of the total biomass of the species – perhaps about 50 per cent. Even though relatively few of those hatchlings would make it to adulthood, the little nipping hordes nevertheless required a great deal of food. Schroeder and her colleagues concluded that the young megatheropods were abundant enough to outcompete other small to medium-sized carnivores by eating small prey, explaining the carnivore gap.

Palaeontologists have moved on from the assumption that gigantic predatory dinosaurs spent their days wrestling gigantic herbivores to the ground. While it is probably true that megatheropods did sometimes attack megaherbivores, we are beginning to build a more complete picture of their diets and behaviour. Some of these enormous predators probably picked off hatchlings and other small animals. Others busted up festering carcasses and yet more probably plucked fish from ancient waterways. In other words, there was no single way to be a megatheropod. The only common denominator may be this: where there was a maw, there was a way. ▮

Riley Black is a writer based in Salt Lake City, Utah. Her most recent book is *The Last Days of the Dinosaurs* (St Martin’s Press)

Climate Action

mediaplanet

The role our buildings play on the road to net zero

Why **poor insulation** could be the wrecking ball for **climate targets**

The world needs to achieve net zero by 2050 if we're to avoid the catastrophic impacts of warming above 1.5°C.

Spread paid for and written by **Kingspan**

Kingspan

Heat leaking from our buildings could be a critical roadblock. A study from BPIE shows that improving wall and roof insulation could reduce the energy demand of homes in selected EU member states by 45%. As the weather turns colder, consumers in poorly insulated homes — already facing energy bills at record highs — could be heating their homes more than necessary.

More efficient buildings

Inefficiencies must be tackled to reduce emissions from one of the world's biggest culprits: the built environment. Buildings are responsible for 37% of energy-related carbon emissions, globally: 27% from heating or cooling our buildings and their consumption of electricity; and 10% from emissions during construction and maintenance, according to the UN Environment Programme.

We must transform the way buildings use energy by making them more efficient. This can only be done by retrofitting the world's existing building stock so it consumes less energy.

Targets still unmet

According to the International Energy Agency (IEA), 20% of buildings need to have a deep retrofit before 2030 for any chance of meeting targets under the Paris Agreement. However, the findings of the Global Retrofit Index — a new report from sustainability consultancy 3Keel with the support of Kingspan, the global leader in insulation — have found that the sector is nowhere near on track.

Judging by the activity of the G20 nations, none of the world's major economies are doing enough to decarbonise their built environments in line with global net-zero targets.

No country in the study (of G20 countries that publish sufficient data, as well as two other European nations with notable retrofit policies) scored well across all the criteria. Even the best-performing European countries have a long way to go to meet the IEA's target retrofit rate of at least 2.5% per year by 2030. Among G20 nations, Germany leads the way, followed by France. Among the G7 members, Canada, USA and Japan ranked lowest.

Utilising existing tools

The sector's energy intensity — energy used per meter of floor space — needs to drop five times more quickly this decade than it did between 2015 and 2020 with a 45% reduction in energy consumed per square meter by 2030. This can only be done through a 50% cut in direct emissions and a 60% cut in indirect emissions, according to the IEA.

This may seem a Herculean task, but the tools and strategies already exist. In the French town of Hem, a housing development has trialled an innovative retrofit model called EnergieSprong. By using low-cost, established technologies including thermal insulation, triple glazing, modern heating systems and prefabricated facades, the movement demonstrates a way to create net zero homes affordably. The cost is generally paid over 30 years by halving household energy bills.

This is just one of the tools and approaches the construction industry has developed to increase the retrofit rates to the IEA's 2.5% annual target.

Global efforts

While the Global Retrofit Index does not list a single country with sufficient retrofit policies in place, it does identify areas of best practice, including the UK Government's plan to phase out new gas boilers in existing residential properties by 2035 and similar ambitions to introduce heat pumps in commercial and public buildings.

In Australia, 30% of homes have a solar photovoltaic system — with the majority installed over the past five years, demonstrating the potential scale of change. California draws praise for its ambitious standards to make all new homes electric-ready while encouraging rooftop solar systems and heat pumps.

Today, a standard retrofit only reduces energy intensity by less than 15%, but around the world, there are examples of how to improve this and make buildings fit for a net zero future. By examining the progress of the world's largest economies, governments can benchmark their progress and get to net zero faster.

i Find out more at **kingspan.com**

i Read the Global Retrofit Index here

AN INDEPENDENT SPREAD FROM MEDIAPLANET WHO TAKE SOLE RESPONSIBILITY FOR ITS CONTENT

What radical measures can we take to **transform the built environment?**

Every site has its unique challenges. But the flexibility provided by today's up-to-date materials allows every building to meet its full energy efficiency potential while meeting the needs of its users.

Buildings are responsible for 37% of global emissions, according to the UN Environment Agency, so creating energy-efficient living and working spaces is essential to meeting global climate targets. Whether it's reimagining old buildings for maximum efficiency or redesigning an industrial facility for sustainability from the ground up, creating a net zero future is well within our grasp.

Energy-efficient homes

Old homes tend to be far less efficient than new homes, but redesigning buildings sensitively can also be challenging. Add this into an urban context where space is at a premium, and the challenge becomes even greater. To solve this problem, architects at alma-nac designed a warm 'coat' for the aptly named 'House-within-a-House.' It has reimagined a 1950s property into a contemporary, energy-efficient design — saving the owners money on heating bills and reducing materials sent to landfills.

The revised design adds an outer envelope to the structure, using Kingspan Kooltherm products to make the energy-efficient vision a reality. The materials were specifically chosen for being thin and lightweight while offering leading thermal performance. Only 50 millimetres of Kooltherm cavity board insulation was fixed between the old structure and new brick frontage, with a further 57.7 millimetres of Kooltherm insulated plasterboard on the inside of the masonry wall. The low thickness allows the design to retain interior space.

Sustainable buildings and large spaces

Retrofitting larger commercial buildings presents other challenges too. At large industrial facilities, for example, space can be a challenge rather than an opportunity. In the design of a new wine bottling facility for Greencroft Bottling, Kingspan's QuadCore PowerPanel was chosen to make the most of the 22,000m2 facility when it completes in 2023. The pitched roofing product not only insulates the huge building effectively but provides the potential to generate over 1.7 million kilowatt hours of electricity per year through its solar photovoltaic capability.

The facility was built to more than double the capacity — up to 400 million litres annually — while prioritising the company's sustainability ethos in terms of reducing energy usage and carbon emissions. The new product used combines energy-saving with power generation to form the ideal roofing solution.

Adding wall insulation to the design helped to create a thermally efficient and virtually airtight building. Greencroft projects that the amount of heat they will need will be just a third of an equivalent building without these sustainability measures, and they will have made a return on investment in just four years.

> *Adding wall insulation to the design helped to create a thermally efficient and virtually airtight building.*

Making use of resources

These projects demonstrate that the onus is on everyone in the built environment ecosystem — designers, owners and end users — all working together to implement the solutions the world needs to meet its net-zero targets. We have the capabilities and tools to drive change and avert the worst impacts of global warming. Now is the time to put them into action.

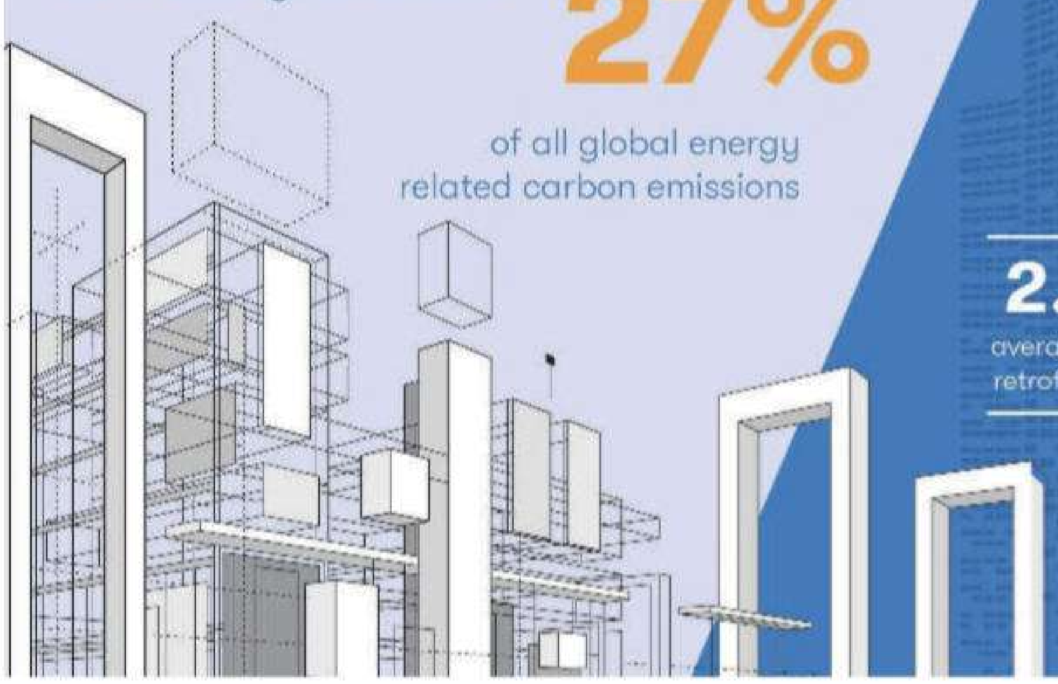
The Global Retrofit Index 2022

Why retrofit buildings?

Heating, cooling and electricity use in buildings accounts for:

27%

of all global energy related carbon emissions



How G20 countries are performing in the Global Retrofit Index 2022:

<1% average annual retrofitting rate

0 G20 countries on track to reduce building emissions in line with net zero by 2050

The targets needed to meet the IPCC1.5 degree scenario by 2030:

2.5% average annual retrofitting rate

45% reduction in energy intensity

60% cut in indirect emissions

50% cut in direct emissions

No.1 in global retrofit rankings
Germany

Lowest among G7
Canada | Japan | USA

HMR

DRUG DEVELOPMENT OPPORTUNITIES AT TRIO MEDICINES LTD

Trio Medicines Ltd (Trio) is a small pharmaceutical company founded in 2007, wholly owned by Hammersmith Medicines Research Ltd (HMR), a Contract Research Organisation (CRO) based in NW London. Currently we have four projects at various stages of development. See www.triomedicines.com

We are seeking a highly motivated life science graduates and PhDs to join our drug development team. Ongoing projects at Trio range from fundamental research in collaboration with academia, through pre-clinical to phase 2 & 3 clinical studies. These projects are supported by chemical synthesis, manufacture, and formulation campaigns.

SENIOR PRINCIPAL SCIENTIST

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As a Senior Principal Scientist, you would occupy a project management role, with key responsibilities including:

- Designing pre-clinical/non-clinical and clinical studies
- Liaising with CROs and Contract Development and Manufacturing Organisations (CDMOs)
- Preparing regulatory documents and liaising with regulatory authorities
- Staying informed of the current literature in the relevant disease areas
- Reviewing a broad range of data to take pivotal project decisions

PROJECT SCIENTIST AND PRINCIPAL SCIENTIST

Project Scientist applicants must have a life science degree in pharmacology, chemistry, or a related subject, and Principal Scientist applicants should hold a PhD in a similar area. Experience of working in research laboratories (within industry or academia) and an understanding of drug development is highly desirable.

Both roles contribute to the management of our drug development programmes, with Project Scientists acting in a supporting role to more senior staff. Key responsibilities include:

- Designing pre-clinical/non-clinical and clinical studies
- Liaising with CROs and Contract Development and Manufacturing Organisations (CDMOs)
- Preparing regulatory documents and liaising with regulatory authorities
- Staying informed of the current literature in the relevant disease areas

Excellent technical, writing and communication skills are essential for all three roles, as is the ability to work both independently and in a multidisciplinary team. We ask for candidates with exceptional organisation skills and attention to detail.

Here at Trio, we are committed to developing science-based medicines to treat diseases with an unmet medical need. We welcome applications from scientifically driven and enthusiastic individuals who share our values

Please specify which of the three roles you are applying for and e-mail a covering letter and your CV to:**Trio@triomedicines.com**

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Twisteddoodles for *New Scientist*
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Science of gardening

Dreaming of a red Christmas

Poinsettias produce a stunning seasonal display of crimson blooms. Learn their secrets to help them thrive, says **Clare Wilson**

Clare Wilson is a staff writer at *New Scientist* and writes about everything life-science related. Her favourite place is her allotment @ClareWilsonMed

What you need

A poinsettia
A light hand with the watering
A dark room, cupboard or bag (optional)

EVERY December, I buy as many poinsettia houseplants as I have room for in my home. These tropical plants, natives of Central America, give a stunning red display that, for many, is a perfect living Christmas decoration.

Each bloom of a poinsettia (*Euphorbia pulcherrima*) is technically an inflorescence rather than a flower, and its "petals" are actually modified leaves called bracts, which turn scarlet in autumn. The real flowers are unimpressively tiny yellow balls at the centre of each cluster.

In its natural state, this shrub is a straggly monster that can reach 3 metres tall. The poinsettias that we see in shops only look the way they do because they are diseased. To make the short, bushy poinsettias that can sit on a windowsill, growers introduce a type of bacteria called a phytoplasma into the plants. This causes them to grow many more side shoots, each terminating in crimson bracts.

The pathogen seems to interfere with the normal process of apical dominance, which is when the tip of a plant's main shoot produces hormones that travel down the stem and inhibit side shoots from growing. This process is why pruning most shrubs can make them more bushy and attractive.

SWNS/ALAMY

To keep your poinsettia looking healthy over the holiday season, don't overwater it, says Andrew Fuller at Bridge Farm Group in Spalding, UK. He recommends waiting until the plant's leaves are just starting to droop, then placing it in a bowl of water for about an hour, which will let the compost take up the right amount of water.

Fuller also advises keeping your poinsettia at a fairly stable temperature. A common mistake is to place it on a windowsill and close the curtains in the evening, leaving it trapped in colder air overnight. The plants don't need high light levels for the month or two they are on display, so would be fine sited well away from a window, says Fuller.

By late January in the UK, most poinsettias will be losing their leaves, but it is possible to encourage them to regrow in spring, and then to coax the new leaves into turning red before next Christmas.

The bracts colour up when the plant detects that the days have become shorter in autumn. So it needs to get darkness for 12 to 14 hours a day for about two months.

In most homes, that won't happen because of the amount of artificial lighting in the evening. Commercial growers such as Fuller achieve the long hours of darkness in their greenhouses by using dark screens or curtains so the plants can be "put to bed" every night.

If you happen to have a spare room that is unlit, your plants could be stored there for two months. Another trick is to put your poinsettia inside a cupboard or place a bag over it every evening – if you have the patience.

Science of gardening appears every four weeks. Share your gardening successes with us on Twitter and Instagram @newscientist, using the hashtag #NewScientistGardening

Next week

Citizen science

These articles are posted each week at newscientist.com/maker

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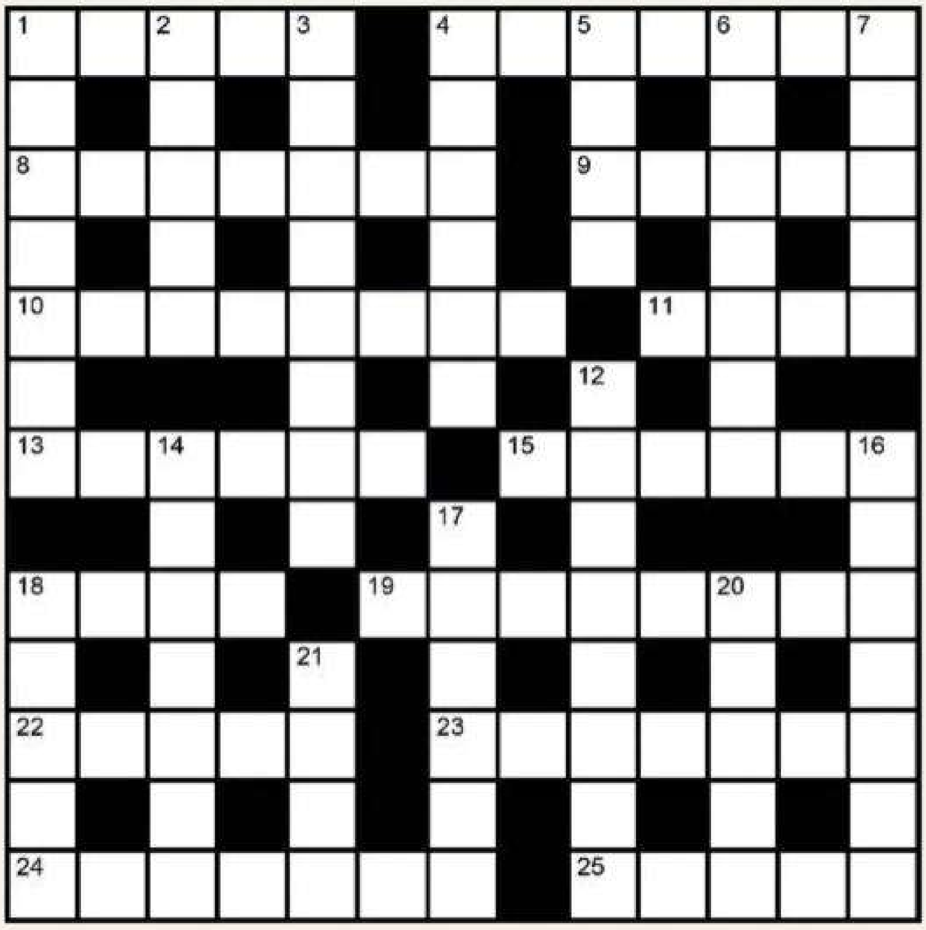
Cryptic crossword #98 *Set by Rasa*



Scribble zone

Answers and the bumper festive crossword next week

ACROSS

1/5 Down Abysmal location had pizza turnover, but no starter (5,4)
4 Unusual fundraising sale announced (7)
8 Pal idly adjusted pond floater (4,3)
9 Leader of herd fills pleasant role in an ecosystem (5)
10 Happy with garlicky condiment lacking a certain bouquet? (8)
11 Sulphur dioxide and bit of tin residue (4)
13 Tidy flan finally polished off (6)
15 In retrospect, study method was tired, apparently (6)
18 Father passing shed by pointy architectural feature (4)
19 He and mathematician Lovelace introducing revolutionary problem (8)
22 Dark spot seen in plum brandy (5)
23 Salty mixture contains essence of some 1 Down (7)
24 Baby bird split bandage (7)
25 Lived close to eight bawdy retreats (5)

DOWN

1 Glow effect caused by ice crystals, germanium, nitrogen and fluorine, say (7)
2 Reportedly handed out a symbol of change (5)
3 Asymmetrical dipoles, wrong battery size (8)
4 Physical lad holds pot top up (6)
5 See 1 Across
6 Masked scavenger ran around cricket club with pair of balls (7)
7 Forcibly remove head of judiciary amid two errors at court (5)
12 Ruffian besieges a road with durable lumber (8)
14 Particular bacteria carried into sea from the bottom (7)
16 Towards sunset, farm mother feeds settler? (3,4)
17 Filtration device label includes each class of vitamins (3,3)
18 Hurt, upset wildebeests eating tons (5)
20 Herb beginning to check honey factory (5)
21 Prepare to take off burden on island (4)

Our crosswords are now solvable online
newscientist.com/crosswords

Quick quiz #181
set by Bethan Ackerley

1 Which of these is a true crab, belonging to the infraorder Brachyura: the European spider crab, the coconut crab or the red king crab?

2 A codon is a DNA or RNA sequence of how many nucleotides?

3 Which 18th-century African-American astronomer is known for his series of almanacs and for corresponding with Thomas Jefferson about racial inequality?

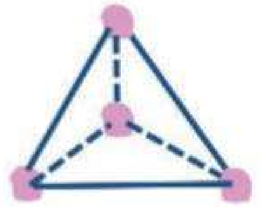
4 In what year were X-rays discovered?

5 Dhul-Nun al-Misri and Ibn Wahshiyya are credited with early attempts to decipher which writing system?

Answers on page 55

Puzzle
set by Zoe Mensch
#197 Marshmallow test

We bought some marshmallows to toast on the fire, but my daughter had other ideas. She started building shapes by joining marshmallows together with cocktail sticks.



In one effort, she put four marshmallows on the table and, keeping them on the surface, joined them with six cocktail sticks, as shown here. To do this, she had to break three of the sticks to the same shorter length (shown by the dotted lines).

"Very neat," I thought, "though she wouldn't have had to shorten any sticks if she'd arranged them as a pyramid."

A few minutes later, she came up with a different way of joining four marshmallows to each other using a fresh batch of six sticks. Again, the marshmallows were flat on the table and three of the sticks were full length, while the other three had been shortened. As before, the three shortened sticks were the same length as each other.

Can you find her other arrangement?

Solution next week

Hot and frothy

Please help settle a friendly argument about coffee. Does a latte cool faster than a cappuccino, all else being equal (initial temperature, volume, etc.)? My friend thinks the foam on a cappuccino will insulate it better, but I reckon this effect is offset by the cappuccino having a smaller volume of hot milk.

@MsAMOne77
via Twitter
Happy to be in the testing team!

Graham Smith
Melbourne, Australia
The heat loss from any surface is proportional to its contact area, multiplied by the temperature difference and also multiplied by a variable called the heat transfer coefficient.

For a cup of coffee, there are two surfaces where heat is being lost to the atmosphere: the cup itself and the surface of the beverage.

When my coffee cup is full of latte, it has 44 square centimetres of latte exposed to the air. There is a large loss of heat from the surface of my latte, because latent heat is being carried away very efficiently by the steam rising from it. In other words, the heat transfer coefficient of this surface is very high.

> “For a cup of coffee, there are two surfaces where heat is lost to the atmosphere: the cup and the surface of the beverage”

My cup also loses heat from about 180 square centimetres of warm glass that is exposed to the air. However, heat loss from this larger surface is less than from the exposed latte because the temperature difference between it and the atmosphere is smaller, and the convective heat transfer coefficient of the glass is much less than the evaporative heat transfer coefficient of the latte surface.

The net result – at least initially, when the coffee is steaming – is that more than half of the heat is lost from the surface of the latte.

Now, what happens if I have a cappuccino, with a third of its volume being froth? Assuming that the froth has little mass and good insulating properties, the heat loss from the glass will be about the same, but there will be minimal heat loss from the liquid surface. Thus the heat loss will be reduced by more than half compared with the latte, while the heat capacity of the liquid, the amount of thermal energy it must lose for its temperature to change by a unit value, will be reduced by only a third, resulting in a lower cooling rate of the cappuccino.

[Ed: Looks like your friend is right!]

DEEPOL BY PLAINPICTURE/SAM EDWARDS

Could a rope be made long, light and strong enough for a tug of war across the English Channel?

This week’s new questions

Super tug **I am fascinated by the idea of a tug of war between Dover, UK, and Calais, France, with thousands of people on each side, 42 kilometres apart. Could a rope be made long, light and strong enough for this?** ***James Campbell**, Canterbury, Kent, UK*

Heavy handed **Why do speakers at public events wave their hands around so much?** ***Jon Blake**, Gisborne, Victoria, Australia*

Want to send us a question or answer?
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Full terms and conditions at newscientist.com/lw-terms

Turn of the screw

Why do loose screws only get looser and not the other way round, even if there seems to be no resistance to the latter?

Geoffrey Clark
Douglas, Isle of Man, UK
I can’t agree that screws always work loose. As a mechanic and general odd-job person, I can assure you that screws and bolts do become tighter – that is why penetrating oils, notably WD-40, were developed.

I have damaged screw heads and bolts in efforts to release them and had to drill them out. I have had more problems with too-tight bolts and screws than I ever had with loose ones. I think it is a perception problem.

Neil Sutcliffe
Glossop, Derbyshire, UK
Screws don’t always get looser! Years ago I had a car with wheel bolts rather than nuts, which progressively tightened and were extraordinarily hard to remove. They required a length of scaffold pipe placed over the wheel wrench to give me more leverage – which caused the wrench to bend.

Rod Sykes
Boudrac, France
How would you know if screws that are still tight hadn’t simply loosened then retightened themselves?

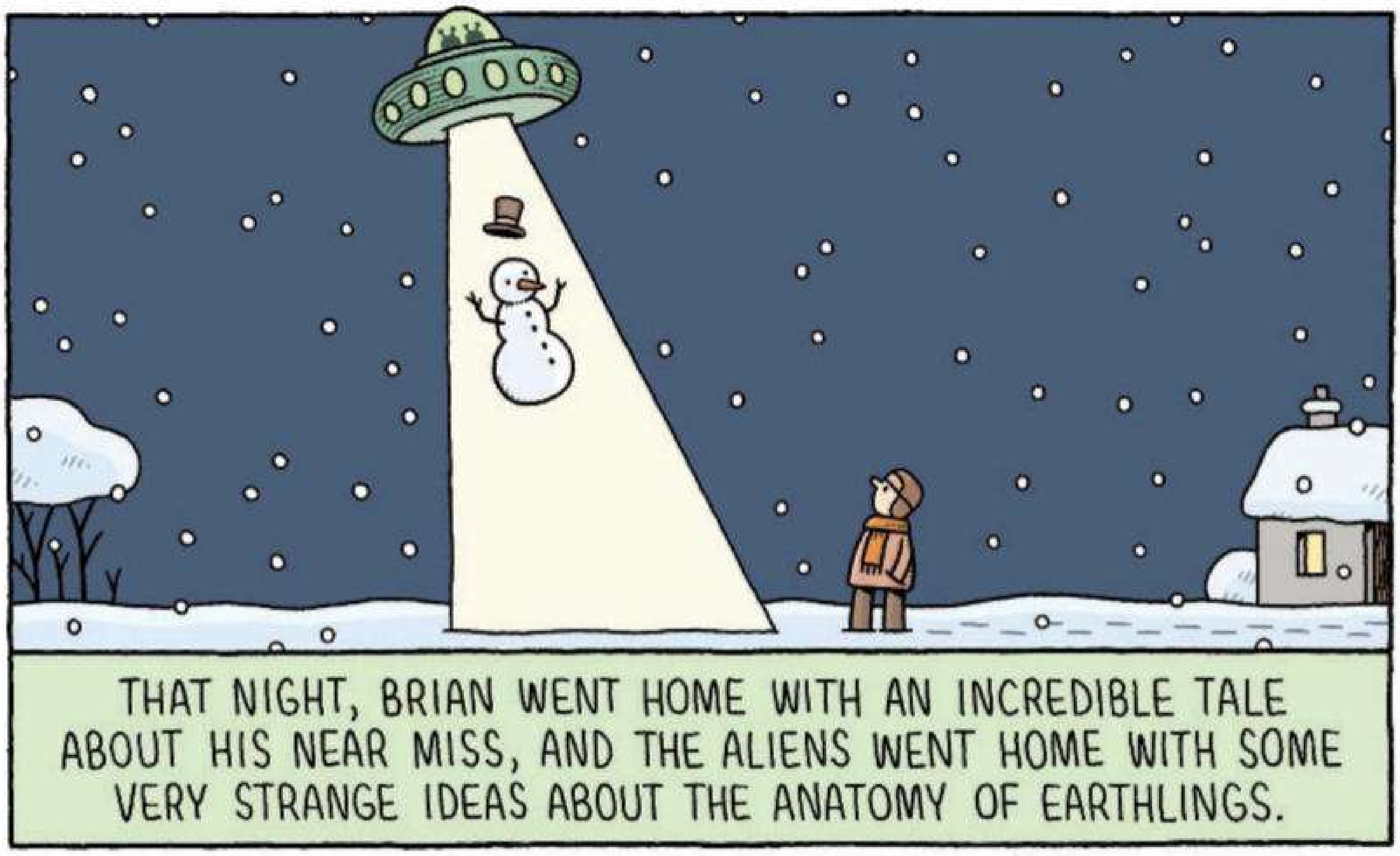
Eric Kvaalen
Les Essarts-le-Roi, France
I question the premise of this question. A screw could sometimes be screwing in and sometimes be screwing out. How would you know? You would have to check its position at different times, and I doubt that the question-poser has done that.

I think the screw probably gets jostled around by vibrations and whatnot, and moves slightly each time, going one way or the other by chance. This is called a random walk. If a screw starts totally screwed in, then obviously when you come and see it some time later, it will be more screwed out.

Geoff Sharpe
Lazonby, Cumbria, UK
A screw or bolt requires more angular force and therefore more energy per degree of rotation the further it is screwed in. This is because there is more thread in contact and more friction. This applies to micro degrees of rotation, each requiring incrementally more force and energy than the last.

Vibration will rotate the screw out because this requires less angular force, and less energy, for each micro degree of rotation compared with rotating it in.

Tom Gauld
for New Scientist


THAT NIGHT, BRIAN WENT HOME WITH AN INCREDIBLE TALE ABOUT HIS NEAR MISS, AND THE ALIENS WENT HOME WITH SOME VERY STRANGE IDEAS ABOUT THE ANATOMY OF EARTHLINGS.

John Davies
Lancaster, UK
One word: entropy. To tighten the screw puts energy into the assembly, which is released to the environment as heat if it loosens.

Pat French
Telford, Shropshire, UK
You can think of a bolt as a spiral, like a helter-skelter. When you tighten the bolt, you are putting energy into the system; you are lifting the load higher and higher up the helter-skelter and increasing its potential energy.

You are also increasing the pressure with which the nut and bolt are forced together, so increasing the friction between them.

This friction holds back the potential energy, just as rubber-soled trainers can hold back someone on a helter-skelter. However, by forcing one face of the bolt thread against the nut, you are also widening the gap on the opposite face. Vibration can move the bolt in this space and release some of the potential energy, and the load slides a tiny way down the helter-skelter.

Once started, this repeats until there is no energy differential between the nut and the bolt, meaning the joint is loose. Even the vibration of a 50 cycle AC electric current can have this effect on the screws in plugs and wall sockets, hence the advice to have them checked occasionally.

You might think that, once the forces required for clockwise and anticlockwise rotation are equal, the direction should be as often one way as the other, but this isn't always so. The very smallest of factors, such as the microscopic variations of the two threaded surfaces, or the nature of any contamination or lubricant present, could bias the rotation to go one way or the other.

The direction that these factors affect rotation will vary. It is all luck and entropy.

> **"I can't agree that screws always work loose. I have had more problems with too-tight screws than loose ones"**

Running water

How fast would you have to travel to be able to run on water? (cont'd)

Paul Greenwood
Lugano, Switzerland
You can "run" on water by being pulled behind a speedboat on waterskis, and it is even possible to do this barefoot, although it requires a fast boat. When you do this, you are standing on a fast-moving stream of water, rather than actually walking. The relative speed between the water and the skier is horizontal, but the angle between the feet and the water deflects water downwards, creating an upward reaction force on the skier's foot. The speed required depends on your weight and the size of your feet. For most adults, you need to be travelling at about 55 to 60 kilometres per hour, although I once taught an 11-year-old to do it at 45 km/h. ▮

Answers

Quick quiz #181
Answers

1 The European spider crab (*Maja squinado*)
2 Three
3 Benjamin Banneker
4 1895
5 Egyptian hieroglyphs

Quick crossword #122 *Answers*

ACROSS 1 *Back To The Future*, **9** Redwood, **10** Faience, **11** Hairs, **12** Lousewort, **13** Ramanujan, **15** Casei, **16** Roots, **18** Haematoma, **20** Entheogen, **23** Vices, **24** Alidade, **25** Galileo, **26** No-hiding theorem

DOWN 1 Bernhard Riemann, **2** Cadmium, **3** Thousands, **4** Tidal, **5** Effluence, **6** Urine, **7** Urn moss, **8** Electrical storm, **14** John Glenn, **15** Coalville, **17** Ostrich, **19** Oscular, **21** Eland, **22** Night

#196 Champion trainer
Solution

The winning horse in the race was trained by Harry Trotter.

The total number of points awarded are 9 + 8 + 7 + ... + 1, which equals 45, so the trainers each got 15 points. The only combinations of points totalling 15 are 951, 942, 861, 852, 843, 762, 753 and 654. Kate had two consecutively placed horses with another finishing behind them, so her points could only be 7-6-2 or 6-5-4. Harry got 1 point for the last horse, so his must be 9-5-1 or 8-6-1, but we know that one of Kate's got 6 points, meaning his scores were 9-5-1 and he trained the winning horse. The points awarded to Kate were 7-6-2 and Britney 8-4-3.

Turning point

For bedtime reading to preschoolers who love engineering, there is nothing quite like "Influence of dimple textures on the tribological performances of tapered roller bearings under starved lubrication", published recently in *Industrial Lubrication and Tribology*. The title is a vocabulary builder and a soporific. However, the details may be too complex for the youngest youngsters.

So... how to foster a toddler's yen to engineer? Tell them about things that roll. Things that rotate. Feed their fondness for things that seem to go round and round without necessarily going anywhere. Tempt them with facts about ball bearings.

Tell them that many things that turn, turn on the ability of many things to turn with minimal friction and vibration. These, in turn, depend on the skill of the engineers who measure the roundness of ball bearings and other mechanical components that spin.

Tell them that insights make possible later insights, each gained through painstaking experiment and measurement. For example, a study in 2004 examined "the effect of ball bearing waviness". A year later, engineers were treated to the publication of a paper called "The influence of location of balls and ball diameter difference in rolling bearings on the non-repetitive runout of retainer revolution".

And that paper, in its own turn, led to a study published this year in the journal *Scientific Reports*. It is called "Influence of roundness errors of bearing components on rotational accuracy of cylindrical roller bearings".

The authors lament that "there is relatively little research on the rotational accuracy of rolling bearings". For youthful great explorers, keen for adventure, this unmapped territory beckons.

Twisteddoodles *for New Scientist*

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A biting issue

A toothy smile can be a pretty sweet prelude to violence. David Sweet and Iain Pretty tried to make that clear in their study "A look at forensic dentistry – part 2: teeth as weapons of violence – identification of bitemark perpetrators", published in the *British Dental Journal* in 2001. "Human bitemarks are most often found on the skin of victims," they write, adding to the drama thus: "they may be found on almost all parts of the human body".

Pretty and Sweet didn't stop there. Nine years later they published "A paradigm shift in the analysis of bitemarks". Their new message: be wary, because the appearance of bite marks cuts both ways. They describe evidence that skin, especially cadaver skin that is used for research into bite marks, isn't "an accurate material" for recording and preserving bite marks. Pretty and Sweet conclude: "Bitemarks have the ability to exonerate the innocent, protect children from harmful caregivers, and convict the guilty. However, they also may be the enemy of natural justice."

This year, Pretty took on a sweeter subject. He co-authored a study about "Bedtime routines intervention for children". The rituals that first-time parents try to establish for very young children – routines "ideally including toothbrushing", says the study – can be instilled rapidly. The trick is to have someone send the parents text messages filled with support and information every night.

Four years ago, Pretty also peered into the story, and not a very sweet one, of older people and their teeth. The Pretty team looked at what happens when you ask some older folk the question: "What would you fear happening to your mouth?"

The answer, as described in a study in the *International Journal of Health Services*: plenty.

On arithmomania

The new study "Playfully Studious Teaching as a Reparative Affective Replacement for Microfascism", by Nick Kasparek, published in the *Journal of Curriculum and Pedagogy*, includes things that may be unfamiliar to non-specialists. Perhaps most intriguing is the mention of a 2019 study called "Arithmomania and the art of rounding", by Fidelio Tata.

"Arithmomania is the clinical description of a mental disorder causing people to engage in obsessive-compulsive counting," explains Tata, offering this example: "During presentations, some people feels [sic] the urge to verify row and column sums in data tables."

Tata explains that, commonly, presenters tweak their numbers "to give them the appearance of being correct". The tweaking takes a toll on any people with arithmomania in the audience. Tata suggests that when preparing a talk that includes data tables, one can do anyone with arithmomania a kindness by including a sudoku in the presentation.

This condition is an intriguing puzzle to brain scientists and psychiatrists. Two, at least, of its medically reported causes are a bit grisly. A report in the journal *Revue Neurologique*, called "Obsessive-compulsive behavior (arithmomania). Atrophy of the caudate nuclei", was published in 1992. More than four decades earlier, C. Boittelle explained in *Annales Medico-Psychologiques* how one patient's condition was a side effect of surgery. The paper's title neatly summarises the affair: "Severe obsessive psychoneurosis in the form of arithmomania, result of lobotomy".

Maddeningly, for scientists and people with arithmomania, and for those who count themselves as being both, the exact number of causes for the condition could turn out to be uncountable. ▮

Marc Abrahams

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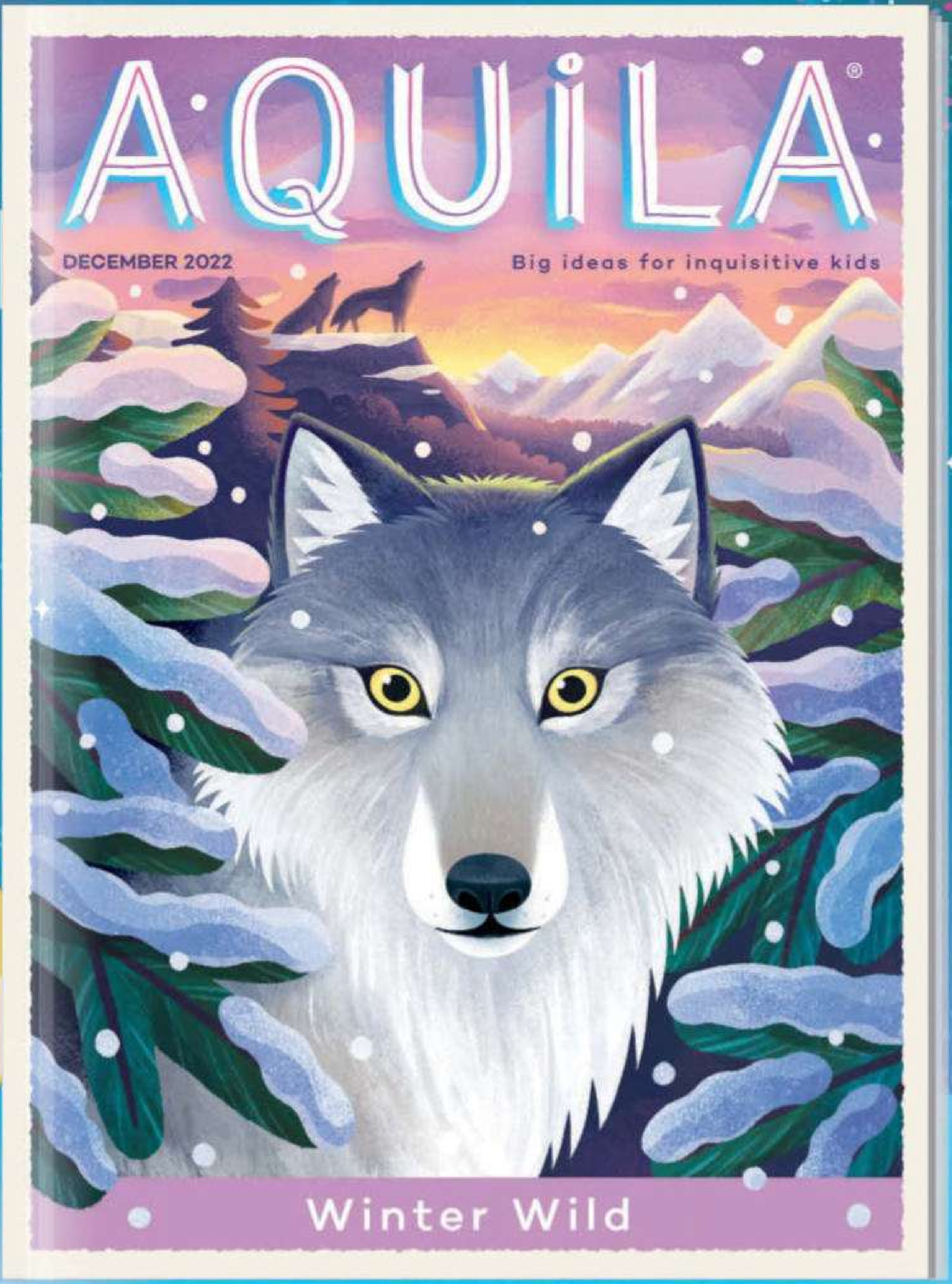

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